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Integrated Environmental and Economic Accounting 2003

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Organisation for Economic Co-operation and Development
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Foreword

The revision of the H*andbook of National Accounting: Integrated Environmental and Economic Accounting* (commonly referred to as the SEEA)[1], presented in this volume has been undertaken under the joint responsibility of the United Nations, the European Commission, the International Monetary Fund, the Organisation for Economic Co-operation and Development, and the World Bank. Much of the work was done by the London Group on Environmental Accounting, through a review process that had started in 1998.

The present Handbook provides a common framework for economic and environmental information, permitting a consistent analysis of the contribution of the environment to the economy and of the impact of the economy on the environment. It is intended to meet the needs of policy makers by providing indicators and descriptive statistics to monitor the interaction between the economy and the environment as well as serving as a tool for use by strategic planning and policy analysis in identifying more sustainable development paths.

The Handbook covers complex and diverse topics, some of which are still subject to debate. Whenever possible, it reports best practices and, where a variety of approaches exist, it presents their advantages and disadvantages. Even though a single recommendation could not always be given, the Handbook represents a major step towards harmonized concepts and definitions, and will provide the basis for the further development of standards.

The revision process has required numerous meetings over several years in which experts in environmental accounting throughout the world have participated. The revised SEEA owes much to their collective advice and wisdom. At the same time, the revision has been a major exercise in cooperation between national and international statistical agencies. It may serve as a model for future collaborative work on the development of improved statistical systems and standards. The revised SEEA is intended for use by both national and international agencies in compiling environmental accounts reflecting their information needs and priorities.

The publication of this Handbook was endorsed by the Statistical Commission of the United Nations. It is jointly published by the five organizations mentioned above.

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Preface

Explanatory notes

The symbols that have been used in the tables, figures and boxes throughout the Handbook are explained directly below:

.. **Two dots** indicate that data are not available or are not separately reported.

- **A dash** indicates that the amount is nil.

- **A hyphen** (-) indicated that the item is not applicable.

. **A full stop** (.) is used to indicate decimals.

Details and percentages in tables do not necessarily add to totals, because of rounding.

The following abbreviations and chemical formulae have been used:

ABS	Australian Bureau of Statistics
ADI	acceptable daily (human) intake
AN	non-financial asset (in the SNA asset classification)
AP	acidification potential
AWRC	Australian Water Resources Council
BAT	best available technology
BOD	biochemical oxygen demand
CAS	Chemical Abstracts Service
CBS	Central Bureau of Statistics (Netherlands)
Cd	cadmium
CEC	Commission of the European Communities
CEPA 2000	Classification of Environmental Protection Activities and Expenditure
CFC	chlorofluorocarbon
	consumption of fixed capital
CGE	computable general equilibrium
CH_4	methane
c.i.f.	cost, insurance, freight (used for trade figures)
CO	carbon monoxide
CO_2	carbon dioxide

COD	chemical oxygen demand
COFOG	Classification of the Functions of Government
COICOP	Classification of Individual Consumption According to Purpose
COPNI	Classification of the Purposes of Non-Profit Institutions Serving Households
COPP	Classification of the Outlays of Producers According to Purpose
CORINAIR	Coordination of Information on Air Emission (in Europe)
CORINE	Coordination of Information on the Environment (in Europe)
CPC	Central Product Classification
Cr	chromium
CS	capital service flows
Cu	copper
CV	contingent valuation
D	depletion
da-	"damage-adjusted" (as a prefix to GDP, GNI etc.)
DETR	Department of the Environment, Transport and the Regions (United Kingdom)
DKr	Danish kroner (currency unit)
DMC	domestic material consumption
DMI	direct material input
DMO	domestic material output
dp-	"depletion-adjusted" (as a prefix to GDP, GNI etc.)
DPO	domestic processed output
EA	environmental asset (in the SEEA asset classification)
ea-	"environmentally adjusted" (as a prefix to GDP, GNI etc.)
ECE	Economic Commission for Europe (of the United Nations)
ecu	European currency unit (forerunner of the euro)
EDP	environmentally adjusted net domestic product (term used in SEEA 1993)
EEZ	exclusive economic zone
EFTA	European Free Trade Association
EIOT	environmental protection input-output table
EMAS	European Eco-Management and Audit Scheme
EP	eutrophication potential
EPA	Environmental Protection Agency (Sweden)
EPE	environmental protection expenditure

EPEA	environmental protection expenditure account
EPER	environmental protection expenditure and revenues
ESA	European System of Accounts
ESN	energy supply in the Netherlands
EU	European Union
EVRI	Environmental Valuation Reference Inventory (United States and Canada)
EWC	European Waste Catalogue
FAO	Food and Agriculture Organization of the United Nations
Fmk	Finnish markka (currency unit)
f.o.b.	free on board (used for trade figures)
FRA 2000	Global Forest Resources Assessment
GARP	Green Accounting Research Project
GDP	gross domestic product
ge-	"greened economy" (as a prefix to GDP, GNI etc.)
GNI	gross national income
GOS	gross operating surplus
GREENSTAMP	GREEned National STAtistical and Modelling Procedures
GWP	global warming potential
H^+	hydrogen ion
ha	hectare
HFC	hydrofluorocarbon
Hg	mercury
IC	intermediate consumption
IEA	International Energy Agency
IFEN	Institut français de l'environnement
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ISIC	International Standard Industrial Classification of All Economic Activities
ITSQ	Individual transferable share quotas
ITQ	Individual transferable quotas
IUCN	World Conservation Union (formerly the International Union for the Conservation of Nature and Natural Resources)
kmsr	kilometre of standard river

LCA	Life-cycle analysis
m	metre
M	maintenance costs
MFA	material flow accounting
MIPS	material intensity per service unit
N_2O	nitrous oxide
N	nitrogen
NABS	Nomenclature for the Analysis and Comparison of Science Programmes and Budgets (Eurostat)
NACE	Statistical Classification of Economic Activities in the European Community (Nomenclature statistique des activités économiques dans la Communauté européenne)
NAICS	North American Industry Classification System
NAM	national accounting matrix
NAMEA	national accounting matrix including environmental accounts
NAS	net additions to stock
nc	not classified
NDP	net domestic product
n.e.c.	not elsewhere classified
NGO	non-governmental organization
NH_3	ammonia
Ni	nickel
NIER	National Institute of Economic Research (of Sweden)
NMVOC	non-methane volatile organic compounds
NNI	net national income
NOAA	National Oceanic and Atmospheric Administration (of the United States of America)
NOEC	no observable effect concentration
NOS	net operating surplus
NO_x	nitrogen oxides
NPISH	non-profit institutions serving households
NPV	net present value
NR	not recorded
NSCB	National Statistical Coordination Board (of the Philippines)

O_2	oxygen (gaseous)
O_3	ozone
ODP	ozone depleting potential
OECD	Organisation for Economic Co-operation and Development
P	phosphorus
PACE	pollution abatement and control expenditures
PAH	polyaromatic hydrocarbon
PCDF	polychlorinated dibenzofuran
PFC	perfluorocarbon
PIM	perpetual inventory method
PIOT	physical input-output table
PJ	petajoule
PM_{10}	particulate matter of size 10 microns or smaller
PPP	polluter pays principle
PTB	physical trade balance
R&D	research and development
RIVM	National Institute of Public Health and the Environmental (Netherlands)
ROW	rest of the world
R	rate of interest
RR	resource rent
rV	income element of resource rent
RV	resource value
SAM	social accounting matrix
SBI	sustainable budget index (of Botswana)
SEEA	System of Environmental and Economic Accounting
SEEAF	System of Environmental and Economic Accounting for Fisheries
SERIEE	European System for the Collection of Economic Information on the Environment (Système européen de rassemblement de l'information économique sur l'environnement)
SF_6	sulphur hexafluoride
SFA	substance flow analysis
Skr	Swedish kronor (currency unit)
SNA	System of National Accounts

SNI	sustainable national income
SO_2	sulphur dioxide
SO_x	sulphur oxides
TBFRA 2000	Temperate and Boreal Forest Resources Assessment
TDO	total domestic output
TMC	total material consumption
TMI	total material input
TMO	total material output
TMR	total material requirement
TNO	Netherlands Organisation for Applied Scientific Research
toe	tons of oil equivalent
TWh	Terawatt-hour
UNFCCC	United Nations Framework Convention on Climate Change
UNU	United Nations University
V	stock value (of a natural resource)
VAT	value added tax
VOC	volatile organic compounds
VPA	virtual population analysis
WRI	World Resources Institute
WTA	willingness to accept
WTP	willingness to pay
Zn	zinc

Chapter I. Introduction to the SEEA 2003

A. Introduction

1. Objective of the present Handbook

1.1 The effect of mankind's activity upon the environment has been an important policy issue throughout the last part of the twentieth century. On the one hand, there has been growing concern about the impact of each country's economic activity upon the global and local environment. On the other hand, there has been increasing recognition that continuing economic growth and human welfare are dependent upon the services provided by the environment. These services include the provision of raw materials and energy used to produce goods and services, the absorption of waste from human activities, and the basic roles in life support and the provision of other amenities such as landscape.

1.2 These concerns translate into questions whether environmental endowments are being used responsibly. Are they posing a threat to economic development now, either by being used up too quickly with no prospect of replacement or by generating a level of pollution that threatens human health and the existence of species? Even if current activities do not pose such a threat at present, could they do so if continued without change into the future? These are the basic questions underlying the desire for sustainable development.

1.3 The purpose of the present Handbook is to explore how sets of statistical accounts can be compiled that permit investigation and analysis of the interaction between the economy and the environment. Only by integrating the two areas can the implications for sustainability of different patterns of production and consumption be examined or, conversely, can the economic consequences of maintaining given environmental standards be studied. Policy makers setting environmental standards need to be aware of their likely consequences for the economy. Those determining the development of industries making extensive use of environmental resources either as inputs or as sinks need to be aware of the long-term environmental effects.

1.4 The topic is wide and the handbook extensive. While significant progress has been made in the last few years, this is an area where active research and investigation are still proceeding. Where best practices have emerged, these are reported. When there is still a division of opinion about how best to proceed, the alternatives are presented with arguments for and against each option. Nevertheless, wherever possible, this handbook presents harmonized approaches, concepts and definitions that should provide the basis for the development of standards, and it contains advice on how to compile environmental accounts and carry out analysis based on them.

2. Structure of the present chapter

1.5 Section B of the present chapter looks at the question of sustainability. The three most common interpretations of sustainability, the so-called three-pillar approach, the ecological approach and the capital approach, are presented. The usefulness of the Handbook of National Accounting: Integrated Environmental and Economic Accounting (SEEA) as a framework for operationalizing each of the three is discussed.

1.6 Section C introduces the four categories of accounts that are examined in the handbook. These are (a) physical and hybrid flow accounts; (b) accounts that portray the environmental transactions in the existing System of National Accounts (SNA) (Commission of the European Communities, International Monetary Fund, Organisation for Economic Co-operation and Development and United Nations, 1993) in more detail; (c) environmental asset accounts in physical and monetary terms; and (d) accounts that show how existing SNA aggregates can be modified to account for depletion and degradation of the environment and for environmental defensive expenditure.

1.7 Section D gives a very rapid overview of each of the following chapters, presenting them within the context of the four accounting categories described in section C.

1.8 Section E looks at a number of issues related to implementing the system and includes a discussion of present limitations and areas for future work.

B. Sustainable development and the SEEA

1.9 Many of the concerns related to resource depletion and environmental degradation are reflected in the concept of sustainable development. According to its most widely accepted formulation, that of the World Commission on Environment and Development (Brundtland Commission):

> "Humanity has the ability to make development sustainable - to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987, p. 8).

1.10 The Brundtland Commission left its definition intentionally vague so that the concept of sustainable development would not be confined to any particular category of needs. While this was helpful in terms of the simplicity and wide appeal of the message, the Brundtland definition offered little in the way of a measurable objective for sustainable development. Not surprisingly, in the time since the Brundtland report, researchers from many disciplines have attempted to operationalize the concept. Their goal has been to understand its implications for the current and future path of development. The result has been the emergence of a number of diverging views of sustainable development. Broadly speaking, three currents of thought are evident within the range of views, which can be referred to for convenience as the three-pillar approach, the ecological approach and the capital approach. The basic tenets of these approaches are presented below and the applicability of the SEEA to each in respect of measurement is discussed.

1. The three-pillar approach to sustainable development

1.11 A widely held view of sustainable development is that it refers at once to economic, social and environmental needs. According to this view, there must be no single focus (or object) of sustainability, but instead all of the economic, social and environmental systems must be simultaneously sustainable in and of themselves. Satisfying the needs represented by any one of these three sustainability "pillars" without also satisfying the needs represented by the others is deemed insufficient for the following reasons. First, each of the three pillars is independently crucial. Second, the needs represented by each of the three pillars are urgent and little time is available for debating which ones should be addressed first; they must therefore be addressed simultaneously. Finally, the three pillars are interconnected. There is therefore a risk of unwittingly causing (or worsening) problems in one system while attempting to correct problems in another. The only sure way to avoid this is to so integrate decisions as to ensure that effects in all three systems are considered before action is taken (Robinson and Tinker, 1998).

1.12 The three-pillar approach to sustainable development is wide-ranging and complex. The SEEA has a great deal to offer with regard to certain elements of the approach and less to offer with regard to others. Clearly, the SEEA provides for the compilation of much information relevant to environmental and economic systems, but has relatively little to offer towards understanding social systems. As for the interactions between the three pillars, the SEEA has clearly a great deal to say about the interaction of environmental and economic systems (indeed, it concerns little else), but less about economic/social interaction and social/environmental interaction.

2. The ecological approach to sustainable development[2]

1.13 Central to the ecological view of sustainable development is the notion that economic and social systems are subsystems of the global environment. It follows that sustainability in the economic and social spheres is subordinate to sustainability of the environment. Development, from the ecological viewpoint, is seen to refer to the "capacity of (an ecosystem) to respond positively to change and opportunity" or the "maintenance of (ecosystems') dynamic capacity to respond adaptively" (Golley, 1990). The key property with respect to sustainability, then, is the capacity of ecosystems to respond with resilience to external perturbations and changes.

1.14 A strong current within the ecological viewpoint is the notion that the "health" of ecosystems must be protected and enhanced if they are to exhibit the resilience that is necessary for sustainability. Ecosystem health is a metaphor derived from the human health sciences which is difficult to define precisely. In simple terms, it can be thought of as a "resource" that enables ecosystems to adapt and evolve in the face of changing circumstances.

1.15 The ecosystem health approach to sustainable development implies measurement within two broadly defined categories. The first includes measures of the "pressures" placed on ecosystems by human activities (material and energy extraction, physical restructuring, pollutant emissions, human appropriation of space and ecosystem productivity etc.). These pressures are often the cause of reduced ecosystem health as manifested in degraded service flows and/or reduced management options. The second category includes measures of the responses of ecosystems to these human pressures. The response measures can be of four types: measures that describe the state of the ecosystem; measures that describe the causes of changes in the state of the ecosystems; measures that describe the likely changes in ecosystems in the face of known pressures; and measures of the capability of ecosystems to deal with imposed pressures.

1.16 Despite the utility of the SEEA for addressing the data needs of the ecological approach to sustainable development, the system's full power (which lies in the integration of environmental and economic data) is not fully exploited by an approach focused exclusively on ecosystems. This power is best exploited by the last of the three broad approaches to sustainable development noted above, the capital approach.

3. The capital approach to sustainable development

1.17 The capital approach to sustainable development is most closely associated with the thinking of economists on the subject, although the approach goes well beyond what is typically encompassed by the domain of economics (see, for example, Daly and Cobb, 1989; Pearce, Markandya and Barbier, 1989; Pearce and Turner, 1990; Victor, 1991; El Serafy, 1996). It borrows the concept of capital from economics, but broadens it in a variety of ways to incorporate more of the elements that are relevant to the sustainability of human development. In doing so, it takes concepts from the physical sciences (especially ecology and geography) and from the non-economic social sciences and integrates them within a framework based on capital.

[2] The present section draws heavily upon Rapport (1995).

1.18 Although one finds a certain amount of disagreement among economists regarding sustainable development, substantial agreement exists on one point, namely, that sustainable development is closely related to the long-standing economic concept of income. Most economists refer back to Hicks's (1946) definition of income in this regard:

> "Income is the maximum amount an individual can consume during a period and remain as well off at the end of the period as at the beginning."

1.19 The Hicksian concept of income is easily explained with a simple example. Imagine an individual whose only source of income is a stock portfolio valued at $1 million at the beginning of a year. This is a very well managed portfolio, paying its owner a net return of 10 per cent annually. In this case, the investor's annual income – the maximum amount that he/she can consume in a year without depleting his/her capital investment (that is, his/her stock portfolio) – is $100,000.

1.20 Although there are obvious and important differences between the economic affairs of an individual and those of an entire nation, the above definition of income applies equally well to both. The income of a nation can thus be defined as the amount that it can collectively spend during a period without depleting the capital base (or wealth) upon which it relies to generate this income.

1.21 The advent of sustainable development has altered the way in which many economists think about national income and its relationship to national wealth. In the past, economists tended to focus on produced capital as the underpinning of wealth and therefore of income. To the extent that natural resources were considered at all, they were seen to be free gifts of nature in effectively limitless supply. In recent years, with the emphasis of sustainable development on the preservation of the productive capacity of the environment, many economists have argued that the contribution of a nation's natural capital cannot be ignored in discussions of the sustainability of national income and wealth. Others have added that human capital and social capital must also be considered. This has led to the following interpretation of sustainable development from a capital standpoint:

> Sustainable development is development that ensures non-declining per capita national wealth by replacing or conserving the sources of that wealth, that is, stocks of produced, human, social and natural capital.

1.22 Although human and social capital are important topics and are currently the subject of considerable debate and research, they clearly do not fall under the rubric of integrated environmental and economic accounting. For this reason, they are considered no further here. Likewise, produced capital is not treated at great length in the SEEA and readers interested in learning more about it are referred to other sources, in particular the SNA.[3] Where the SEEA has a great deal to offer is in the area of measurement of natural capital. The remainder of this section is therefore devoted to a discussion of natural capital and its relationship to sustainable development, and to what the SEEA offers by way of a measurement framework for natural capital.

Natural capital and sustainable development

1.23 Natural capital is generally considered to comprise three principal categories: natural resource stocks, land and ecosystems. All are considered essential to the long-term sustainability of development for their provision of "functions" to the economy, as well as to mankind outside the economy and other living beings. It is helpful to consider these functions as falling into one of the following three groups:

[3] Produced capital is treated in two elements of the SEEA framework – the first in the asset accounts, where cultivated natural resources are treated as produced capital; and the second, in the environmental protection and resource management accounts, where produced capital employed for environmental purposes is measured.

(a) Resource functions, which cover natural resources drawn into the economy to be converted into goods and services for the benefit of mankind. Examples are mineral deposits, timber from natural forests, and deep sea fish;

(b) Sink functions, which absorb the unwanted by-products of production and consumption: exhaust gases from combustion or chemical processing, water used to clean products or people, discarded packaging and goods no longer wanted. These waste products are vented into the air or water (including sea water) or buried in landfill sites. These three destinations are often referred to as “sinks”;

(c) Service functions, which provide the habitat for all living beings including mankind. Some aspects of habitat are essential, such as breathing air and drinking water. These are called survival functions. If the quantity and quality of survival functions are diminished, the biodiversity of species, not excluding the human species, is threatened. Some service functions, though not essential in the same way, improve the quality of life, for example, by providing a pleasing landscape for leisure pursuits. These are called amenity functions and affect mankind only (or at least they are the only ones measurable by us in human terms).

1.24 According to the capital approach, the long-term sustainability of development is seen to depend upon the maintenance of natural capital (in addition to the other forms of capital). If stocks of natural capital decline to the point where they are no longer able to adequately provide the functions listed above, any pattern of development that relies on these functions is not sustainable. Of course, this is not to say that some other pattern of development is not possible, only that change will be required to either (a) eliminate the need for a particular natural capital service or (b) find a means of replacing the natural capital service with a service of produced capital.[4]

1.25 Even if many researchers accept the basic idea that sustainable development requires maintenance of natural capital, the relationship between natural capital and other types of capital remains a matter of debate. Although there is agreement that all forms of capital are important when considering sustainability, there is a divergence of opinion whether the various forms are complements or substitutes (especially whether natural capital can be replaced by other forms). Many researchers argue that produced capital and human capital are very often, if not always, substitutes for natural capital. Society has, they note, by way of example, employed produced and human capital to develop chemical fertilizers that substitute for the natural fertility of the soil. Even soil itself can be replaced in a limited way through the use of hydroponics. History is full of similar examples where technological advancement has allowed substitution of scarce resources with those that are more abundant. Many would claim there is every reason to believe that such advancement will continue, even at increased rates, in the future.

1.26 Others argue that the possibilities for substitution are more limited, even completely absent in some cases. Many forms of capital, they argue, are of value only when combined with other forms. For example, a fishing fleet (produced capital) is essentially worthless unless combined with healthy fish stocks (natural capital) that can be exploited. In this case, the fishing fleet and the fish stocks are said to be complementary. However, this is just a limited example of complementarity, where a subset of one type of capital is complementary to a subset of another type of capital. Another possibility is that there exists a certain form of capital that provides a service that is essential to the functioning of the entire

[4] Sewage treatment plants are a good example of the latter. Because sewage production far exceeds that which rivers can accept without suffering a dramatic decrease in functioning, society has been forced to divert financial and human resources away from other purposes into the production and operation of sewage treatment plants. These plants do nothing more than replace the waste assimilation service that the natural capital (rivers) cannot provide at current levels of sewage production.

planetary system and for which there is no known substitute. Although examples of this type of capital are few (and there may be no absolute example), global atmospheric systems that provide the services of protection from solar radiation and climate regulation come close.

1.27 The controversy over the degree of substitutability for natural capital has translated into a continuum of capital-based approaches to sustainable development. At opposing ends of this spectrum are found the concepts of weak and strong sustainability, which may be defined as follows:

(a) Weak sustainability seeks to maintain from year to year the per capita income generated from the total capital stock available to a nation (measured in monetary terms). No regard is given to the composition of this stock, as it is assumed that all forms of capital are substitutes for one another. Weak sustainability clearly allows for the depletion or degradation of natural resources, so long as such depletion is offset by increasing the stocks of other forms of capital (for example, by investing royalties from depleting mineral reserves in factories);

(b) Strong sustainability requires that all forms of capital be maintained intact independent of one another. The assumption implicit in this interpretation is that different forms of capital are mainly complementary; that is, all forms are generally necessary for any one form to be of value. Produced capital used in harvesting and processing timber, for example, is of no value in the absence of stocks of timber to harvest. Only by maintaining both natural and produced capital stocks intact, the proponents of strong sustainability argue, can non-declining income be assured.

1.28 Regardless of which position between these two extremes is accepted, the effect of an increasing population is the same. Not only must capital stocks be non-diminishing, but they must in fact grow at the same rate as the population if per capita income is to remain constant. Of course, the effects of technological change may mean that the population can grow faster than capital stocks with no reduction in income earning potential if technology allows more productive use to be made of existing stocks.

Weak and strong sustainability: implications for natural capital

1.29 The same basic principle is apparent in both the weak and strong interpretations of sustainability, namely, that development must be compatible with long-term maintenance of capital stocks. The implications of this principle for natural capital differ, however, depending upon which interpretation one accepts.

1.30 Under a regime of weak sustainability, natural resource stocks may be depleted, and environmental systems degraded, but only if this depletion/degradation is offset by equivalent or greater increases in other forms of capital; that is, so long as there is no reduction in total capital, development is assumed to be sustainable.

1.31 Since it is the total capital stock that is to be maintained, all forms of capital must be measured using the same yardstick. Practically speaking, this implies measurement of natural capital in monetary terms.

1.32 Strong sustainability requires that natural capital stocks be maintained intact independent of other forms of capital. In practice, this requires invoking certain principles for the use of natural capital. Inherent in these principles is the notion that prudence should be applied when making decisions about natural capital. Our limited scientific understanding of the environment requires that this be so. While it may eventually turn out not to be necessary to maintain a particular form of natural capital, it is dangerous to assume this and fore-close future options. Sustainability, we are reminded, is a problem over the long run as much as – or more than - one concerning the current period. The caution called for by strong sustainability is often expressed in terms of the "precautionary principles" set forth below:

(a) Renewable resources should not be used in excess of their natural regeneration;

(b) Non-renewable resources should be used prudently and efficiently with care that the same function is available to future generations, say, is accepted by technological development or shift to use of renewable resources;

(c) Sink functions should not be used beyond their assimilative capacities;

(d) Activities that cause deterioration in service functions should be avoided or at least minimized.

1.33 Because strong sustainability requires the independent maintenance of capital stocks, there is no reason why all forms of capital must be measured using the same unit of measure. This allows for measurement of natural capital stocks in physical units as well as in monetary units. Physical measurement of natural capital is often straightforward. Stocks of many natural resources (for example, subsoil and timber assets) can be measured using simple physical units. Measuring the natural capital represented by environmental systems – the waste assimilation capacity of a river system, for example – is much more difficult. The SEEA includes accounts designed to measure such ecosystem services, but it must be noted that current knowledge and experience in this field are limited. The ecosystem accounts presented in the SEEA should then be viewed as works in progress. They will evolve along with understanding of ecosystems and the services that they provide.

4. The SEEA as a framework for measuring sustainable development

1.34 It is clear from the foregoing that the SEEA can serve as at least a partial framework for measuring sustainable development using all three of the broad approaches noted. The system has not been designed to serve any particular perspective and, indeed, should be of considerable value regardless of the user's particular point of view on the concept. This said, it is clear that the focus of the SEEA on macrolevel accounts integrating environmental and economic data makes it particularly useful from the perspective of the capital approach. The SEEA has the capacity to respond to data needs across the full range of views within this approach. How this is so will be made clearer in the next section, in which the SEEA accounting system is described in its broad outlines.

C. Overview of the SEEA accounting system

1.35 The SEEA is a satellite system of the SNA that comprises four categories of accounts. The first considers purely physical data relating to flows of materials and energy and marshals them as far as possible according to the accounting structure of the SNA. The accounts in this category also show how flow data in physical and monetary terms can be combined to produce so-called hybrid flow accounts. Emissions accounts for greenhouse gases are an example of the type included in this category. The accounts of this category are outlined in chapters III and IV of the Handbook.

1.36 The second category of accounts (see chaps. V and VI) takes those elements of the existing SNA that are relevant to the good management of the environment and shows how the environment-related transactions can be made more explicit. An account of expenditures made by businesses, governments and households to protect the environment is an example of the accounts included in this category.

1.37 The third category of SEEA accounts comprises accounts for environmental assets measured in physical and monetary terms. Timber stock accounts showing opening and closing timber balances and the related changes over the course of an accounting period are an example. These accounts are described conceptually in chapter VII.

1.38 The final category of SEEA accounts considers how the existing SNA might be adjusted to account for the impact of the economy on the environment. Three sorts of adjustments are considered; those relating to depletion, those concerning so-called defensive expenditures and those relating to degradation. Chapters IX and X cover this material.

1.39 The objectives and usefulness of the accounts in each of these categories are discussed in more detail below.

A note on terminology

1.40 The various accounts of the SEEA may be expressed in either physical or monetary units, or both. The accounts expressed in physical terms may employ any of the linear, volumetric, area or mass units used in the International System of Units (for example, metres, litres, hectares or kilograms). For convenience, all such accounts are referred to generically as "physical accounts" in this Handbook. The accounts expressed in monetary terms are, of course, presented using only currency as the unit of measure. These accounts are referred to generically in what follows as "monetary accounts". The term "monetary" in this case is synonymous with "economic value" as the latter is understood in economic theory. In particular, the measures included in the monetary accounts of the SEEA should be taken to reflect the objective weighting that is brought to bear through the use of socially determined relative prices.

1. Category 1: Physical and hybrid flow accounts

1.41 Many environmental data sets are now available that show the extent to which the precautionary principles listed above are respected. Often different data sets are collected and published for different sorts of environmental resources. The physical flow accounts of chapter III bring a set of common measuring tools to bear on these currently disparate data sets. The framework chosen is that of the SNA. The objective is to see the extent to which the economy is dependent on particular environmental inputs and the sensitivity of the environment to particular economic activities.

1.42 Bringing the data together in a framework using common classifications helps to highlight any inconsistencies and gaps in the overall picture. It also allows links to be made to other economic series. Does an industry that is environmentally sensitive play a particularly large role in international trade of the country or provide many employment opportunities? If common units can be used, the possibility of aggregation and the presentation of simple indicators are facilitated.

1.43 Once the physical data are aligned with economic classifications, an obvious next step is to compare the physical quantities with the matching economic flows. This is developed in the SEEA by means of hybrid accounts (chap. IV), which make up the remainder of the first category.

1.44 Hybrid environmental accounting is a means of juxtaposing physical information about the use of environmental resources with information in both physical and monetary terms about the processes of economic production. The combination of different types of units of measure accounts for the term "hybrid".

1.45 The key sustainability policy goal to which hybrid accounts correspond is the desire to maintain or improve economic performance while simultaneously reducing or eliminating the impact on the environment. This process is sometimes referred to as "decoupling". Decoupling can be brought about by shifting consumption and production patterns away from materials with environmentally damaging consequences, by adopting new technologies that make more efficient use of environmental resources reduce the damage done by existing production patterns.

2. Category 2: Economic accounts and environmental transactions

1.46 The environment's relationship to the economy is based not only on its use as an input. Increasingly, activities are undertaken and products created with the deliberate intention of relieving pressure on the environment. Thus, besides examining (using the hybrid accounting structure) where pressures exist, it is also desirable to identify where expenditure is undertaken to alleviate or rectify these pressures. This is the objective of the accounts described in chapter V.

1.47 In addition to direct intervention in the state of the environment via environmental protection expenditure, economic instruments are an increasingly common means of encouraging environmentally friendly behaviour. These instruments may take the form of taxes to discourage consumption by increasing prices or of licences and permits to exercise control over property rights and access to environmental media. Measuring the use of these types of instruments is the objective of the accounts in chapter VI.

1.48 The relationship of the accounts in this category to the measurement of sustainability is somewhat indirect. Clearly, expenditures made to reduce the pressure on the environment are an important measure of the human response to the sustainability challenge. However, the level of the expenditures themselves does not reveal directly whether development has become more sustainable or not. In order to assess this, one must turn to other categories of accounts within the system. What the accounts in this category do allow, however, is an assessment of the economic costs and benefits, including their sectoral impact, of reducing the human impact on the environment. This is highly important information for those interested in analysing sustainability from a fiscal perspective.

3. Category 3: Asset accounts in physical and monetary terms

1.49 The environment can be thought of in natural capital terms as a collection of assets of various types. As noted earlier, natural capital falls into three broad categories: natural resources, land and ecosystems. Category 3 of the SEEA includes asset accounts in physical and monetary terms for each of these three broad categories. The methods for compiling these accounts are described in chapter VII.

1.50 When natural resources are used in a production process, they are embodied in the final good or service produced. The price charged for the product contains an element that implicitly covers the value of the natural resource. Establishing this implicit element is at the heart of valuing the stock of the resource and taking into consideration the full role of the resource in the production activity of extracting the resource and making it available to other units in the economy.

1.51 The asset accounts of the SEEA are highly relevant to the measurement of sustainable development from the capital perspective. Natural resources, land and ecosystems represent the stocks that provide the many environmental inputs required to support economic activity. If such activity is to be sustainable, the capacity of natural capital stocks to furnish these inputs must be maintained over time or the economy must find a substitute for the natural capital that is capable of delivering an equivalent input. If both of these conditions are not met, the current pattern of development is not sustainable.

1.52 The debate over the concepts of weak and strong sustainability mentioned earlier is germane here. The weak sustainability viewpoint is essentially one of technological optimism in which it is assumed that the economy will always find a substitute for any scarce resource given the right price signal. The strong sustainability viewpoint takes the position that it is imprudent to assume that the economy will always find a substitute for natural capital because (a) the past technological successes do not assure success in the future; and (b) we do not know all there is to know about natural capital functioning and we therefore risk unexpectedly losing key inputs if we allow natural capital to be depleted or degraded.

1.53 Whatever perspective one takes on weak and strong sustainability, the asset accounts of the SEEA are fundamental to understanding the evolution of sustainability. Clearly, if one assumes a position of strong sustainability, the direct measures of natural capital provided in the asset accounts furnish essential information. Even if one assumes a weak sustainability perspective, one would still wish to know how much natural capital is being consumed so that this might be compared with investments in other forms of capital with a view to assessing whether total capital is being maintained.

1.54 The asset accounts are also relevant to the intra- and inter-generational equity issues of sustainable development. In a number of countries, natural resources are owned and controlled by the government on behalf of the population at large. It is thus important to be able to see where income is derived from the use of the resource and how it is apportioned between the extractor and the owner.

4. Category 4: Extending SNA aggregates to account for depletion, defensive expenditure and degradation

1.55 The final category of the SEEA (chaps. IX and X) deals with the extension of the existing SNA aggregates to account for depletion and degradation of natural capital, as well as for so-called defensive expenditures related to the environment. Not every statistical office will be in a position to make such extensions (as they are data-intensive and methodologically complex) and (as they can be controversial) not every office will wish to do so. Nevertheless, it is the logical culmination of the SEEA to explore the possibilities as well as to note the theoretical, practical and institutional hurdles encountered in doing so.

1.56 The use of resource functions raises the question whether the resource is being depleted and if so whether the allowance made in the economic accounts for maintaining produced capital intact (the consumption of fixed capital) should be augmented by a term that might be called the consumption of natural capital.

1.57 Some of the expenditure in the economy relates to attempts to avoid using the sink function of the environment. This includes environmental protection expenditure and may include other expenditure of a type that might be described generally (albeit not very precisely) as defensive expenditure.

1.58 Putting a value on the actual use of the sink function remains a much more difficult problem than the two mentioned directly above. While it might be possible to make some order-of-magnitude estimates for marginal changes in the use of the sink function, comprehensive estimates go beyond standard accounting into the realm of modelling.

1.59 Like the asset accounts of chapter VII, the extended aggregates presented in the SEEA are highly relevant to the measurement of sustainability from the capital perspective. However, unlike the asset accounts, which are relevant from both the weak and the strong sustainability perspectives, the accounts in category 4 implicitly adopt the perspective of weak sustainability. The aggregate measures that are described in the SEEA can be constructed only by first valuing all forms of natural capital and then aggregating the value of natural capital with the value of produced and financial capital already included in the SNA.

D. Structure of the Handbook

1.60 The present section gives a very brief overview of each of the chapters in the handbook. At the start of each chapter, there is also a more extensive "road map" describing the objectives of the chapter and providing a brief description of its contents.

1. Chapter II: The accounting structure of the SEEA

1.61 This Handbook is a statistical publication and pervading all the chapters are accounts and tables that it is suggested could be compiled to illuminate the various issues under discussion. Chapter II provides an overview of the whole accounting system. This can be read either at the outset as a preliminary overview of what is to follow or finally as a synoptic review of the interconnections between the accounts and tables in different chapters.

1.62 As an aid to understanding, a synthetic data set for an artificial country, SEEAland, has been created. This country shares some of the characteristics of several industrialized countries; solely in the interest of making the examples easier to follow, however, it is better endowed with natural resources than any one of them and its economy has potentially more damaging impacts on the environment.

1.63 The description of the accounting structure for the whole Handbook is illustrated in chapter II with summary versions of tables for SEEAland. More elaborate and more detailed versions appear in subsequent chapters. A summary table at the end of chapter II is included as a reference with respect to the interrelations among the various tables.

2. Chapter III: Physical flow accounts

1.64 Chapter III is the main chapter concerned with compiling flow accounts in physical terms. It is designed to show how the use of the environment can be monitored and documented in physical terms by using classifications and definitions consistent with the economic accounting structure of the SNA.

1.65 This chapter looks at physical flows of materials and energy in connection with the goods and services produced within the economy and contains examples of life cycle analysis for wood and timber products and an example of total material flow analysis. It elaborates a system that can provide indicators warning of threats to sustainability based only on physical data.

1.66 Chapter III introduces four concepts that are fundamental to the discussion presented throughout the Handbook. These concepts are products, natural resources, ecosystem inputs and residuals. The concept of product is taken over from the SNA. The accounting system of the SNA measures the flows of products (economic goods and services) and shows how, in a closed economy, some are used to produce other goods and services in the current period (intermediate consumption) or in future (capital formation) and how some are used to satisfy current human wants (final consumption). This closed economy must be opened up to take account of transactions with the economies of other countries via imports and exports.

1.67 The SEEA opens up the system further by looking at the flow of entities into the economy from the environment and those flowing from the economy to the environment. The environmental inputs flowing to the economy from the environment can be divided into natural resources (typically mineral and biological resources) and ecosystem inputs (the water and air necessary for all life forms). The flows from the economy to the environment consist of gaseous, liquid and solid wastes. In the SEEA, the term "residual" is used to encompass all these outflows from the economy that use environmental media as a disposal sink.

1.68 The first part of chapter III describes the overall framework within which accounts can be compiled for each of these four concepts and discusses the classifications of products, natural resources, ecosystem inputs and residuals that can be used in the accounts.

1.69 The last part of chapter III considers the indicators and analyses that can be derived from the accounts, and shows how the law of the conservation of matter can be invoked to demonstrate how natural resources, ecosystem inputs and products may be combined to supply products to be used within the economy or residuals to be expelled to the environment. The table expressed in physical units that presents this transformation is referred to as a physical supply and use table and forms the basis of material flow analysis. Both these techniques have potential as powerful analytical devices based only on physical flow accounts.

3. Chapter IV: Hybrid flow accounts

1.70 Chapter IV shows how a standard SNA supply and use table can be superimposed on the corresponding part of the physical table described in chapter III. The result is a hybrid supply and use table where the columns contain values of products plus the cost of labour and capital and in addition physical inputs of natural resources and ecosystem inputs, while the rows contain values of products and physical measures of residuals.

1.71 Such a hybrid table is particularly useful for relating the generation of residuals to the production of particular industries. One of the most useful and most frequently compiled examples concerns energy accounts and the associated emission generation.

1.72 Although the economics of production leads to specialization, some industries make more than one product and some products are made by more than one type of industry. The supply and use tables described in chapter III and the first part of chapter IV reflect this fact of life and show supply classified by industry, and use classified by product. It is very useful analytically to so convert the format of these tables as to show either the supply and use of products or the supply and use by industries. A table so converted as to have the same classification along both axes is called an input-output table. The last part of chapter IV explains how these can be constructed from the earlier tables. Further, it shows why such conversion is useful analytically.

1.73 If we know the proportionate environmental input into a product, say, and we know who uses the supply of this product, then we can calculate with a fairly good degree of approximation the total environmental input of all products. For example, we can cumulate the environmental input into iron and steel, into various chemical products, into tyres and so on to find the total direct and indirect demands placed on the environment in order to produce a car. It may sometimes appear that the direct demands on the environment made by the economy fall when in fact all that happens is that the demands are made via another economy. One example concerns electricity. Country A may not consume fossil fuels to produce electricity; however, if it imports electricity from country B, which simply generates it by burning fossil fuels, the reduced dependence of country A on fossil fuels is more apparent than real. Analysis of input-output tables for both A and B can give insights into these sorts of issues.

4. Chapter V: Accounting for economic activities and products related to the environment

1.74 Increasingly, steps are being taken to protect the environment. Chapter V looks at how the expenses connected with environmental protection can be identified within the present SNA and shows whether it is purchased, produced for sale or undertaken on an own-account basis. By making these expenses explicit, the impact on operating costs of government legislation or voluntary agreements to improve environmental protection can be studied.

1.75 The chapter describes a variety of environmental protection and resource use activities, such as investment in clean technologies, restoring the environment after it has been polluted, recycling, production of environmental goods and services, conservation, and management of natural assets and resources; and also outlines the uses and the limitations of the information, describes the basic concepts involved, and sets out the internationally agreed classifications needed to describe the various elements in the accounts.

1.76 Chapter V discusses simple national aggregates that can be produced, such as the level of investment in the protection of the environment compared with the total investment in the economy, in order to show the relative national effort devoted to environmental protection; and then describes simplified supply and use tables that show the connection between producers and consumers of environmental protection goods and services, the types of economic inputs used (such as labour and capital) and the type of outputs produced (whether for the market or for own use). This is followed by an analysis of the ways in which expenditure on environmental protection is financed.

5. Chapter VI: Accounting for other environmentally related transactions

1.77 Chapter VI describes other monetary transactions connected with the environment, specifically those economic instruments increasingly being used to manage the use of environmental resources. These are the imposition of taxes with an environmental base and the issuing of licences and permits to bestow property rights over environmental resources to designated users.

1.78 These flows are captured within the SNA. The accounts can be portrayed in a matrix form to include such flows as taxes and payments for the use of assets as well as the flows of a supply and use table for products. Such a matrix presentation, which is often referred to as a social accounting matrix (SAM), can also be represented in a hybrid table where physical measures of environmental inputs and residual outputs are added to the flow accounts of the SNA. This matrix is often referred to as a NAMEA (national accounting matrix including environmental accounts). Chapter VI shows how such a table can be constructed and how the matrix form of presentation can be used to incorporate alternative classifications of the same concept, for example, consumption classified by product and by (economic) function, as a means of transforming the links between residuals and products into a link between residuals and economic functions.

6. Chapter VII: Asset accounts and the valuation of natural resource stocks

1.79 Chapter VII looks at environmental assets and discusses how to account for changes in these assets in both physical and monetary terms. This permits the calculation of indicators showing to what extent the stock of a given asset is being sustained or not in both physical and monetary terms.

1.80 This chapter contains the main discussion on the classification of environmental assets, which are divided into natural resources, land and ecosystems. The first category distinguishes between renewable and non-renewable resources, between economic assets covered by the SNA and those outside the SNA boundary, and between assets that may be consumed by the economy (such as subsoil assets and biological resources) and those that are used but not consumed by the economy such as land and surface water.

1.81 The chapter then discusses the principles behind physical asset accounts, that is, getting from opening stock levels to closing stock levels by itemizing the flows within the accounting period. A distinction is drawn between changes in quantity and changes in quality. The chapter then relates the stocks and flows in physical terms to the transactions and accounting entries of the SNA. It also discusses to what extent a pure environmental classification can be used in monetary terms and to what extent some compromise with economic classifications is inevitable when valuation is involved.

1.82 The principles of economic valuation are discussed in chapter VII and related to the theory of the provision of capital services to the production process by fixed assets. The application of this theory to environmental assets which are currently regarded as "free" gifts of nature is discussed as the basis for reaching a valuation of the stock of these assets. There is detailed discussion of the manner of valuing each of the main classes of assets.

7. Chapter VIII: Specific resource accounts

1.83 Chapter VIII takes the general considerations from the previous chapter and shows how these can be applied to specific resources. There are separate sections on mineral and energy resources, water, wooded land, timber and forest products, aquatic resources, land and ecosystems.

8. Chapter IX: Valuation techniques for measuring degradation

1.84 This chapter is concerned exclusively with the valuation techniques that could be applied to derive measures of degradation. In some cases, prices observed in the economy can be used in respect of environmental services that are currently unpriced. Some of the pricing techniques described are entirely consistent with national accounts but represent more analytical means of pricing various characteristics of a product. One example involves the use of a hedonic price index.

1.85 Within the national accounts, the prices used reflect the prices actually paid in the marketplace. The assumption is that the economic value is reflected precisely by market prices. This economic value should not be equated with welfare or well-being. Indeed, there is no attempt made within the SNA to measure welfare, although the macroeconomic aggregates of the SNA are sometimes misinterpreted as welfare measures. The explicit omission of the additional values that would be required to produce an estimate of welfare is an important element in the objective measurement of economic activity in the SNA.

1.86 Often, the satisfaction to be gained by acquiring a product is greater than the purchase price and the purchaser would in fact be prepared to pay more for the product than the asking price. This excess of the level of satisfaction over the asking price is described as consumer surplus. Some of the pricing techniques discussed in chapter VIII include an element of consumer surplus. There are a number of very cogent reasons why consumer surplus is deliberately not included in the SNA, yet if we try to measure the impact of degradation on welfare we are forced back towards pricing techniques that include consumer surplus. These prices are not strictly consistent with the prices used in the SNA and thus present accounting problems in respect of trying to assimilate them within an SNA-based framework, as explored in chapter X.

1.87 Even without making adjustments to the macroeconomic aggregates, investigating possible monetary valuations for degradation can be revealing. It broadens the understanding of the impact of degradation on those who suffer from it. It opens the door to undertaking cost benefit analysis such as may be undertaken, for example, in project-specific valuations. Statisticians will wish to know the current thinking on the topic for this reason if for no other.

9. Chapter X: Making environmental adjustments to the flow accounts

1.88 This is the chapter leading up to the derivation of aggregates adjusted to some degree or other for the impact of the economy on the environment. It discusses three sorts of adjustments: those relating to depletion, those concerning defensive expenditure and, lastly, degradation.

1.89 The first section examines how depletion of environmental assets could be incorporated in the SNA. The basis of the proposition is the following: just as part of the gross domestic product (GDP) represents the consumption of fixed capital and is deducted to give a measure of net domestic product or income that is more in keeping with the notion of preserving a capital base, so that part of GDP that represents the consumption of natural capital should likewise be deducted to reach a "depletion-adjusted" set of aggregates.

1.90 The second section is concerned with defensive expenditure. It discusses why simply deducting defensive expenditure from GDP gives figures that are unsatisfactory from an accounting point of view. It goes on to suggest how, purely within the context of a satellite account, the work described in chapter V to identify environmental protection expenditure could be used to reach a solution where all defensive expenditure was treated in the same way in the accounts, regardless of whether it was a market-oriented enterprise that undertakes it, government that produces it or households that consume it.

1.91 The third section discusses extending the SNA to show the possible implications of appending valuations to aspects of degradation that are currently unpriced. Inasmuch as its content is at the furthest remove from current national accounting practices, it is the most controversial and most tentative section. It describes work that is currently only in the research stage – work that is not yet, and may not be, incorporated into the work programme of most statistical offices.

1.92 The chapter moves from actual accounting into the area of hypothetical accounting. Its aim is to try to quantify the impact in monetary terms of the use of sink functions beyond their assimilative capacity. The economic paradigm whereby cost would be incurred up to the point where it was matched by economic benefit does not operate because the costs would be incurred by one set of agents (producers) and the benefits would fall to another (consumers, future generation and non-human species). What actually happens is that costs are avoided by the producers and damage is suffered by consumers, widely interpreted. One approach is to try to estimate what it would cost producers to avoid overusing the sink functions. The other is to try to estimate some of the damage done by the overuse. In effect, this is trying to estimate the value that could be placed on the service function for humans.

1.93 For short-term practical implementation, experience since the publication of the interim version of the SEEA in 1993 suggests two main options for valuing degradation. The first of these relies on cost-based estimates and can in turn be divided into two types. The second option relies on damage-based estimates.

1.94 The first cost-based option is to assume that the valuations represent real costs that have actually been paid by producers and consumers, and to calculate what the national accounts would look like if this assumption held true. The calculations produce aggregates based on the idea that the costs involved are those required to maintain a given environmental standard. The aggregates that this leads to are denoted as being "environmentally adjusted" in keeping with the terminology of the 1993 SEEA.

1.95 The second cost-based option is to assume that the valuations represent costs and benefits which, if they were taken into account by producers and consumers, would affect their behaviour. The solution to the overuse of environmental functions is not to change the accounting system but to change the economy and its demand on the environment. The effects are therefore modelled using the conventional national accounts to produce a similar range of aggregates known as "greened economy" aggregates.

1.96 The damage-based option tries to estimate the loss of welfare caused by the effect of residual generation on human health and thus, but not exclusively, on human capital. The rationale for this route to adjusting macro-aggregates is the furthest removed from the normal SNA conventions and impinges on the realm of welfare measurement.

10. Chapter XI: Applications and policy uses of the SEEA

1.97 Chapter XI looks at the techniques developed in the preceding chapters and shows how these may be used to inform policy analysis and decision-making.

1.98 The chapter begins by looking at how the causes of environmental degradation can be examined, mainly using the techniques from chapters III and IV. This material is of particular interest to those wishing to examine how to “decouple” the traditional pattern of residual generation from economic production.

1.99 Environmental degradation can be combated by a number of means, some compulsory and some voluntary. The accounts for environmental protection expenditure from Chapter V can be used to explore many of the associated issues, including the options for extending environmental protection expenditure undertaken in the economy. Increasingly, government seeks to achieve environmental standards through activities involving market instruments such as imposing new taxes and reducing subsidies as well as introducing permits and licences to restrict the unlimited use of environmental resources, rather than by introducing those standards through legislation. These applications often use economic models in conjunction with the accounting structures described in chapter VI, allowing for a more comprehensive assessment of the effects of introducing new environmental legislation, such as the impact on employment or unanticipated environmental benefits.

1.100 Sustainability concerns not just the use of environmental media as sinks but also the use of natural resources. Environmentally responsible policies must consider the use of natural resources and other issues associated with the maintenance of national wealth. In addition, policy makers will be interested in knowing who benefits from the income generated by natural resource exploitation and the efficiency with which these resources are managed.

1.101 Although the consequences of environmental degradation are often not incorporated within the accounting system, analysis looking at the merits of alternative policies can be more firmly based if the costs and benefits of the different proposals are examined in a common metric. This is where the techniques described in chapter IX can be used. More tentative at present is the extension of such work to more comprehensive measures of sustainable income based on the techniques described in chapter X.

1.102 While the SEEA does not attempt to define a given set of indicators of sustainable development, compiling such sets is now common in many countries and international organizations. Often the SEEA framework can provide relevant information and the list prepared by the United Nations Commission on Sustainable Development is examined in this context. With the SEEA as a background, a set of indicators can be chosen that is more consistent than a set of independently selected indicators and that provides better linkages between indicators of environmental pressures and responses.

11. Annexes

1.103 Altogether nine annexes are included in the Handbook. Eight of these give details of the various classifications used in the compilation of the accounts described in the various chapters.

1.104 Annex IX describes the technical relationship between the SEEA accounting framework and that of the 1993 SNA. It shows where the SNA has been extended but not changed, and highlights those few cases where change is recommended solely in connection with a satellite account. It also describes those instances where the text of the SNA is perhaps not as clear as it might be in respect of environmentally related transactions and offers a more precise clarification. Lastly, it contains reference to techniques that are mentioned in the SNA but described in greater detail in this Handbook.

E. Implementing the system

1. The relation between the SEEA and environmental statistics

1.105 As an integrated accounting system, the SEEA stands apart from individual sets of environmental statistics in a number of ways. While sets of environmental statistics are usually internally consistent, there is, for good reason, often no consistency between one set of statistics and another. Environmental statistics are often collected with a particular regulatory or administrative purpose in mind and the way in which they are structured is specific to this need.

1.106 In contrast, the SEEA is an integrated system of accounts in which, to the fullest extent possible, there is consistency between one account and another in terms of concepts, methods, definitions and classifications. In addition, implementation of such an integrated system aims for consistency across time. This is of the utmost importance in developing the comparable time-series estimates that are necessary in the policy process. The final important difference between environmental statistics and the SEEA is the latter's explicit goal of achieving compatibility with the economic information of the SNA. This adds considerable value to both the environmental and the economic information, as it facilitates their analysis within a common framework.

1.107 The SEEA may stand apart from sets of environmental statistics in important ways, but it also relies upon them for the basic statistics required in its implementation. Ideally, these statistics would be readily available in a format that allowed their direct incorporation into the system. For example, data on residual emissions from industrial sources would ideally come classified according to the industrial classification used in the SEEA. This would allow their simple incorporation into physical and hybrid flow accounts. In most countries, it is unlikely as yet that most sets of environmental statistics will already be so structured.

1.108 It is reasonable to expect that over time the implementation of the SEEA will result in changes to the way in which environmental statistics are collected and structured in a given country. For this to happen there must exist (or be established) a spirit of collaboration and respect between environmental accountants and statisticians. The former group must understand that collecting data for environmental accounts may be a secondary concern for statisticians responsible for providing information to, for example, a regulatory programme. The latter group must be convinced of the importance of having highly structured and consistent data within an accounting framework. In this regard, it can be helpful to explain how such data can improve the likelihood of environmental information's being considered more fully in the economic decision-making process. The SEEA can serve as a guiding framework for the development of environmental information systems that are more compatible with economic statistics.

2. Flexibility of implementation

1.109 It is important to recognize that, although the SEEA is conceived as a complete system which is internally consistent, its design is such that it can be implemented equally well in part or in whole. Depending upon the specific environmental issues faced, a country may choose to implement only a selection of the accounts included in the SEEA. Even if a country desires eventually to implement the full system, it may decide to focus its initial efforts on those accounts that are most relevant to the issues that it wishes to address. For example, a country with few natural resources may not wish to pursue questions related to resource depletion and therefore would not undertake to compile asset accounts. Even those countries that are resource-rich may wish to concentrate first on those resources that are perceived to represent a risk to sustainability or that are the subject of discussion regarding the way in which government appropriates revenue from their exploitation.

1.110 Countries with high levels of material throughput may find it useful to build physical flow accounts for materials but, again, this may be done on a selective basis, for example, by working first on accounts for specific materials and, perhaps, later building complete physical input-output tables.

1.111 If a country imposes strict environmental standards, with significant cost to producers and consumers, then environmental protection expenditure accounts may be an early priority. Those where there is as yet little active environmental protection may prefer instead to concentrate on the calculation of residuals and their impact in order to discover how urgent the problem of introducing environmental protection is.

1.112 Countries where environmental depletion or degradation has reached the point where it constrains economic activity may be interested in knowing what percentage of their current gross economic output might be consumed by the loss of natural capital. For such countries, the extended aggregates presented in chapter X would be of considerable interest.

1.113 These examples illustrate the flexibility of application of the SEEA, which its structure was intended to permit. It is important to bear in mind, however, that, no matter which elements of the system are implemented, these elements must be implemented in such a way as to be internally consistent and mutually complementary.

1.114 Box 1.1 shows the accounts of the SEEA cross-classified against the three broad environmental issues dealt with in the Handbook (degradation, defensive expenditure and depletion). It indicates which chapter (in boldface) contains the main discussion of the issue and which chapters (enclosed in italicized braces) are prerequisites for the discussions. The box will be of use to those wishing to have an overall view of how the various accounting techniques described in the SEEA can be used to address major environmental issues.

Box 1.1. The environmental issues and accounts discussed in the SEEA

	Degradation	Defensive expenditure	Depletion
Physical accounting based on environmental statistics and economic classifications	**Chapter III** Studies of production in physical terms using the supply and use framework of the SNA Addition of the concepts and similar accounts for natural resource and ecosystem inputs and residual outputs		**Chapter VII** Asset accounts compiled in physical terms; linkage between stock and flow information Extension of the asset boundary of the SNA to include a wider set of environmental assets
Hybrid accounting linking the physical accounts above with economic (monetary) flows in strict accordance with SNA data	*{Chapter III and}* **Chapter IV** Hybrid supply and use tables Derivations of input-output tables and consequential analyses	*{Chapter III, IV, V and}* **Chapter VI** Examination of the SNA sequence of accounts and development of a hybrid matrix of all flows (NAMEA) Sectoral accounts and ownership issues	
Monetary accounting including more detail than SNA data but strictly consistent with it		**Chapter V** Identification of environmental protection expenditure and other defensive expenditure **Chapter VI** Identification of economic instruments to encourage responsible resource management (taxes, licences etc.)	**Chapter VII** Valuation of resource stocks Translation of the link between stocks and flows into changes in wealth and income
Monetary accounting allowing variation in the SNA accounting rules	*{Chapters III,IV and}* **Chapter IX** Valuation techniques applicable for degradation **Chapter X** Possible adjustments to macro-aggregates to allow for degradation	*{Chapters V,VI and}* **Chapter X** Possible adjustments to macro-aggregates to allow for defensive expenditure	*{Chapter VII and}* **Chapter X** Possible adjustments to macro-aggregates to allow for depletion

3. Progression of the system

1.115 The description of the accounting system begins with the physical and hybrid flow accounts. This is an appropriate starting point, since there is access to the basic environmental flow data required to compile such accounts (for example, on natural resource consumption and residual emissions) in many countries and the environmental issues surrounding these flows are widely considered important. Physical accounts are an appropriate starting part for the system as well in that they are almost always a necessary precursor to monetary accounts. Thus, even for countries whose ultimate goal is the production of accounts in monetary terms, the starting point will generally be accounts in physical terms.

1.116 The second category of accounts, in which existing SNA flow accounts are presented in greater detail to make apparent environment-related transactions, represents the basic point of entry into monetary environmental accounting. Countries interested in learning about the economic importance of environmental transactions without modifying existing SNA aggregates can refer to the accounts presented in this category.

1.117 The third category of accounts, asset accounts in physical and monetary terms, has its own internal logic (it could in fact have been presented earlier in the Handbook without disrupting the general logic of the structure). In the description of the asset accounts, as in the overall Handbook, physical accounts are given as the point of entry. Once the concepts related to the compilation of the accounts in physical terms have been presented, the discussion in chapter VII turns to the methods that can be used to place a value on environmental assets. Again, this reflects the notion that physical accounts are generally the starting point even if the ultimate goal is accounts in monetary terms.

1.118 The final category, in which SNA aggregates are modified to account for depletion, degradation and defensive expenditure, is the logical culmination of the handbook. After describing how the environment can be accounted for in purely physical terms, in combined physical/monetary (hybrid) terms and in monetary terms within the existing SNA, the Handbook appropriately concludes by considering how to account for the environment in purely monetary terms by modifying the existing SNA.

4. Comparing accounts in physical and monetary terms

1.119 The interaction between the environment and the economy manifests itself in physical terms. The materials and energy extracted from the environment are physical entities and the changes induced in the environment as a result of economic activity (depletion and degradation) are physical in nature. For this reason, the most direct measures of the interaction between the environment and the economy are physical. If a country's goal in undertaking environmental accounting is to better understand the details of this interaction, it will likely be well served by accounts in physical terms.

1.120 Despite their strengths, it is important to note that physical accounts suffer from important limitations. One such limitation is the general lack of relative weights that could allow aggregation of measures expressed in physical terms. Only in a few instances are such weights available.[5] The majority of physical measures cannot be meaningfully aggregated at this time, making it a challenge to interpret the large amount of information that can be produced from physical accounts.

1.121 Purely physical accounts also suffer from a lack of economic context. Knowing the residual production of a given industry is certainly valuable information, but many would argue that it could be more valuable if measured against the industry's economic performance. For example, residual emissions could be compared with the value of economic output to determine the residuals emitted per unit of production. This would allow meaningful inter-industry comparisons and enrich the use of the physical measures in an economic policy context. The purpose of hybrid accounts is exactly to provide this kind of economic context for physical measures. While improving upon purely physical accounts from an economic perspective, hybrid accounts do not solve the problem of aggregating physical measures.[6] For this, one must turn to accounts expressed in monetary terms.

1.122 The use of relative prices to weight disparate measures in monetary accounts allows the compilation of aggregate measures. Reducing the number of variables that one is required to consider can greatly simplify the interpretation of the information contained in environmental accounts. It also offers the advantage of direct comparison of information in environmental accounts with that derived from economic accounts. For many users, the ability to compare, say, the rate of growth of gross

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[5] A well-known example is the use of global warming potentials to express emissions of greenhouse gases in terms of carbon dioxide equivalent units.

[6] Another potential disadvantage of hybrid accounts may be noted, namely, the possibility that these accounts could create the mistaken impression that a resource's or residual's relative importance in, or impact on, the environment is implied by its economic importance in a production process.

domestic product (GDP) with the rate of growth of environmental degradation is an attractive feature of accounts in monetary terms.

1.123 While attractive, the monetary approach is not without limitations. In particular, its implementation is empirically and conceptually challenging. The techniques available for doing so remain in their early stages of development. They have been created mainly for use in micro level cost-benefit studies and their application in a national accounting context is in its infancy. A great deal of data may be required to implement some of the approaches and these data may not exist completely in many countries. In addition, the techniques can be controversial. Even among those researchers who accept the fact that valuation is a valid approach, there is debate over the most appropriate techniques to use. Some argue that valuation of the environment is to be avoided in any case, either on ethical grounds or for reasons of prudence. The latter argument goes as follows: given our inadequate understanding of the environment, we risk sending the wrong signals by unintentionally omitting key environmental inputs in valuations.

5. Integration in the SEEA framework

1.124 The SEEA is presented as an integrated system of environmental accounts. The interpretation of the term "integrated" is a matter of debate, however. Some commentators argue that the only truly integrated accounts of the SEEA are those that are expressed uniquely in monetary terms. They argue that true integration comes only when all measures in the accounts are harmonized through the application of the same set of relative prices. Only then can each and every measure in the system be compared meaningfully with the others.

1.125 Others take the view that it is sufficient to consider the accounts integrated if they share common concepts, methods, definitions and classifications and that it is not necessary, that they share common units of measure in addition to these other characteristics. Advocates of this view argue that meaningful comparison of measures from various accounts is possible so long as the measures "line up" with one another. There is no need for the measures to actually be combinable into monetary aggregates. In support of this position, they note that the SNA itself includes non-monetary data in some instances (for example, on employment) and that business accounts can include both physical and monetary measures.

1.126 It is not the place of this Handbook to take sides on issues that are still matters of international debate. For this reason, the SEEA does not advocate one perspective on integration over the other. The system is presented in the remainder of the Handbook in as neutral a fashion as possible so that users may make up their own minds about the meaning of "integrated" in the SEEA context.

6. Limitations of present work

Time and space

1.127 The development of environmental accounts is closely linked to the concepts embodied in the SNA. As such, environmental accounts are most suitably compiled for national areas on an annual basis. Environmental issues that are seasonal (such as shortages of water in the summer) or local (such as a reduction in air quality in a particular location) do not lend themselves easily to analysis in the accounts. Although in theory quarterly and regional accounts are feasible, in practice few countries have the data from which to compile such accounts.

1.128 Even where an issue is persistent throughout the year, some environmental effects are highly ephemeral, for example, an emission of biological oxygen demand, while others are very long-lived, such as the generation of certain radio nucleotides. The result is that a year-based account may place the wrong emphasis on the former and ignore the latter except in the year of generation.

1.129 Limited attention is given to some time and space issues in the Handbook. The considerations of importing and exporting demands on the environment are discussed in chapter IV and the question of accumulating “environmental debt” in chapter X. These are both areas where further consideration and elaboration will be fruitful.

Accuracy

1.130 The techniques described in this Handbook have been carefully conceived and in many cases carefully worked out. Nevertheless it is important to be aware that there are still many uncertainties concerning the basic data. Some of these uncertainties may be scientific in origin. The critical threshold of some residuals may as yet be unknown or even the fact that some residual is critical may be unsuspected. The exact shape of the relationship between cause and effect may as yet be measured over only a relatively narrow range of observations and so projections about what may happen outside that range may be in error. Some uncertainties may be statistical. There is less experience in building at least some areas of environmental databases than, say, some areas of economic or social statistics. As techniques of data collection improve, the database is likely to improve and reveal weaknesses in present data sources which, even if suspected, may not be quantified.

1.131 All this leads up to the proposition that any analysis based on the techniques described here should pay attention to the fact that in many cases giving a picture of the likely direction and possible magnitude of the environmental impact of some phenomenon may be as much as the data will bear. Those compiling accounts are urged to emphasize the quality of their estimates (or the lack of it) as honestly and openly as possible for the benefit of those using the results. It is worth noting, however, that different types of analyses require different levels of accuracy. The fact that there remains a high degree of uncertainty about the results may not invalidate some general conclusions being drawn.

Non-environmental changes

1.132 The SEEA accounts link the economy and the environment. Most of the focus is naturally on the technical interaction between the two realms. However, there are other factors which can have major consequences for the demand placed on the environment by the economy. Over time, populations increase and so does the general level of prosperity. Both factors will increase demands on environmental functions. On the other hand, technological developments may come to the rescue by finding more environmentally efficient ways of conducting economic activities.

Coverage

1.133 The system of accounts described in this Handbook establishes links to economic activities as measured by economic statistics. Despite the efforts at bringing the considerations involving physical environmental statistics and those involving economic statistics closer together, it is still difficult to incorporate all environmental concerns into an accounting framework. Some issues relevant to sustainability may not be easily measured in this context. For example, while the SEEA is well suited to measuring the flows of residuals associated with economic activities, it is less well suited to studying the impact of these flows on the health of humans and non-human species.

Catastrophes

1.134 Another issue not well treated is the issue of catastrophes. Some of these, such as flooding and erosion, previously seen as natural events, are now more often perceived to be the consequence of environmentally careless behaviour in the past. Some that are not environmental in origin, such as the wreck of an oil tanker, can have serious environmental consequences. Furthermore, there may be economic actions with environmental consequences as well as further economic consequences. In future, it may be desirable to try to bring some of these into the field of environmental accounting also.

7. An assessment of the current position

1.135 As has already been made clear, the Handbook very much represents work in progress. Developmental work continues in a number of areas and the Handbook itself is likely to need revising again in the not-too-distant future. Three instances can be cited where present work may cause the relevant sections here to quickly become out of date.

1.136 Very few countries have developed a broad range of accounts, and no country has yet developed the full set of accounts. Applications and links between elements of the accounts have therefore not yet been fully explored.

1.137 Environmental issues change as scientific knowledge about harmful substances and practices improves. The classifications, weights and analyses will have to remain open to review in the light of better knowledge. Further, our understanding of the extent to which emissions are damaging will evolve as we gain more sophisticated information about the susceptibility of areas to the release of emissions.

1.138 Some of the techniques, in particular those used to attribute values to environmental goods and services, have not been widely used or accepted and will be subject to further development.

Chapter II. The accounting structure of the SEEA

A. Introduction

1. Objectives of the present chapter

2.1 This Handbook describes a set of accounts covering environmental and economic phenomena. It is important to present an overview of the system as a whole in order to demonstrate where and how consistency between different accounts is ensured. If in the course of implementing a particular account, the conventions suggested in this Handbook are modified, it would be helpful to understand the consequences for aspects of other accounts, even if these are not to be implemented.

2.2 The purpose of the present chapter is to provide an overview of the aspects accounting of covered in the following chapters in order to clarify conceptually how the various accounts form part of an integrated single system. This chapter concentrates solely on accounting aspects. Issues of classification, implementation, data availability and practical experience are discussed in those subsequent chapters that elaborate one account or more.

2.3 Some readers may wish to familiarize themselves with this overview of the whole system at the outset. Others may wish to explore particular aspects of the system first and return to this chapter later to place their investigations in a wider context. Still others may simply wish to use this chapter as a quick cross reference to those parts of the Handbook where detailed aspects of accounting are described. The chapter is intended to serve any of these purposes for different readers or, indeed, for the same reader at different times.

2. The need for an accounting approach

2.4 Economic accounts and environmental statistics have each developed as an independent area subject to its own conventions and classifications. Economic accounting is carried out almost entirely in monetary terms and although the economy operates within the natural environment, the inputs from the environment have until recently been seen as “free”. As a result, the impact of the environment on the economy has not been readily identifiable within the economic accounts. Sets of environmental data are often compiled with specific regulatory or administrative purposes in mind and therefore use a variety of concepts, methods, classifications and units of measurement related to the needs they satisfy. For this reason, disparate sets of environmental statistics are generally not integrated with one another, or with sets of data relating to the economy or society.

2.5 An accounting approach is designed to bring a more systematic discipline to the organization of environmental statistics. It does this by:

(a) Encouraging the adoption of standard classifications in environmental statistics;

(b) Encouraging the development of comprehensive and consistent data sets over time;

(c) Facilitating international comparisons.

2.6 Like the main national accounts, the SEEA accounts serve a score-keeping function from which key indicators can be derived and a management function in that they can be used in the analysis of policy options. The accounts provide a sound basis for the calculation of measures that may already be included in sets of sustainable development indicators, but they may also be used to develop new indicators, such as environmentally adjusted macro-aggregates that would not otherwise be available.

2.7 The potential uses of the environmental accounts, like those of most information systems, are greatly enhanced once a consistent and coherent time series has been established. This requires the accounts to be seen as part of the wider national accounts and produced on a routine basis.

3. Environmental accounts and the SNA

2.8 As the need for an internationally agreed accounting system for monetary flows in the economy has long been accepted, the SNA has been widely used in most countries of the world for many years. Figures such as gross domestic product (GDP) and national income derive from the SNA. The fact that they are derived from an internationally recognized standard helps to ensure not only their comparability across countries but also their credibility. One goal of this Handbook is to begin to foster the same international acceptance of environmental accounting.

2.9 In principle, it would be possible to establish a set of environmental accounts that was quite independent of the SNA. From the outset, however, consistency with the SNA has been a prime motivation for the development of the SEEA. For environmental policy to be most effective, it must be articulated and implemented within an economic context and those making economic policy are familiar with the framework of the SNA. Integrating economic and environmental accounts thus seems the preferred means by which to ensure that economic and environmental policies are also integrated.

SNA satellite accounts

2.10 The guidelines in the SNA originated 50 years ago and have been revised several times since then, most recently in 1993. One aspect of the latest revision was the greater attention paid to capital stocks and flows and, in particular, to the place of natural resources within the set of economic assets, in order to facilitate the linkage to environmental accounting. However, it was also felt at that time to be inappropriate to go any further in incorporating environmental accounting in the central system because work in that area was still maturing. Although much progress has been made since then, major new developments are still likely and so the interface between the economy and the environment is still represented in terms of a "satellite" account.

2.11 It has become common to refer to internal and external satellite accounts. An internal satellite account is simply a rearrangement of the existing SNA transactions. No new flows are added but those that already exist may be presented and aggregated differently and, in some case, separated out from existing records by a process of "deconsolidation". An external satellite account, on the other hand, extends the scope of the system by including stocks, flows and transactions that are not covered by the existing SNA (see also annex IX).

A satellite account for the environment

2.12 The SEEA should be seen as a satellite account of the SNA with features of both internal and external satellite accounts. The full system comprises four categories of accounts, as outlined briefly below (see chap. I for a fuller discussion).

2.13 The first category of accounts in the SEEA considers purely physical data relating to flows of materials and energy and marshals them as far as possible according to the supply and use and input-output frameworks of the SNA. The accounts in this category also show how flow data in physical and monetary terms can be combined to produce so-called hybrid flow accounts. Emissions accounts for greenhouse gases are an example of the type included in this category. The accounts of this category are outlined in chapters III and IV of the Handbook.

2.14 The second category of accounts takes those elements of the existing SNA that are relevant to the good management of the environment and shows how the environment-related transactions can be made more explicit. For this, it is necessary to go beyond the supply and use tables and look at the whole system of the SNA flow accounts including income distribution and redistribution. Environmental protection and resource management are discussed in chapter V. The place of environmental taxes and permits to use environmental resources is discussed in chapter VI.

2.15 The third category of accounts in the SEEA comprises accounts for environmental assets measured in physical and monetary terms. Timber stock accounts showing opening and closing timber balances and the related changes over the course of an accounting period are an example. A description of these accounts, including how natural resources contribute to income and the measure of wealth in the national balance sheet, appears in chapter VII.

2.16 The final category of SEEA accounts considers how the existing SNA might be adjusted to account for the impact of the economy on the environment. Three sorts of adjustments are considered: those relating to depletion, those concerning so-called defensive expenditures and those relating to degradation. Chapters IX and X cover this material. It is more provisional than the rest of the system and has had, for reasons explained in chapter X, less widespread acceptance.

Implications for statistical systems

2.17 In order to investigate the economy/environment interface in quantifiable terms a degree of integration is necessary between the environmental and economic data sets available to a statistical office. In order to represent environmental data in a context derived from economic data, a number of principles, concepts and classifications used by the SNA require modification, elaboration or extension. These broadly concern:

(a) The types and descriptions of activities that are treated as part of production or consumption;

(b) The classifications used to describe production and consumption;

(c) The type and descriptions of assets to be included within the accounts;

(d) The methods used to value stocks of environmental assets and flows of environmental goods and services;

(e) Specification of whether, and if so how, changes in the value of assets affect the measurement of income generated during production.

2.18 Establishing these integrating mechanisms is important and is described in each of the relevant following chapters and the annexes to the handbook. Specific examples drawing on work done are portrayed in various chapters as appropriate but especially in chapter VIII where the implications for each of five main environmental assets (minerals and energy, water, forests, fish and land) are discussed.

The analytical potential of the system

2.19 Devising an accounting structure that relates various environmental and economic phenomena in a coherent and consistent manner is not in itself a sufficient justification for the SEEA. To merit a place in the work programme of a statistical office, the system has also to lend itself to the development of indicators calling on a wide range of data that can provide insight and guidance to policy makers in both the economic and environmental areas. This is the subject matter of chapter XI.

B. Physical flow accounts

2.20 The SEEA sets out to expand the view of the economy by considering the interaction between it and the environment. The SNA considers both value at a point in time (stocks) and changes in these values over time (flows). The SEEA is also concerned with stocks and flows but considers these as measured in physical terms as well as with values placed on them. The starting point for developing the system is to examine flows within and between the economic and environmental spheres in physical terms.

1. The economy/environment interface

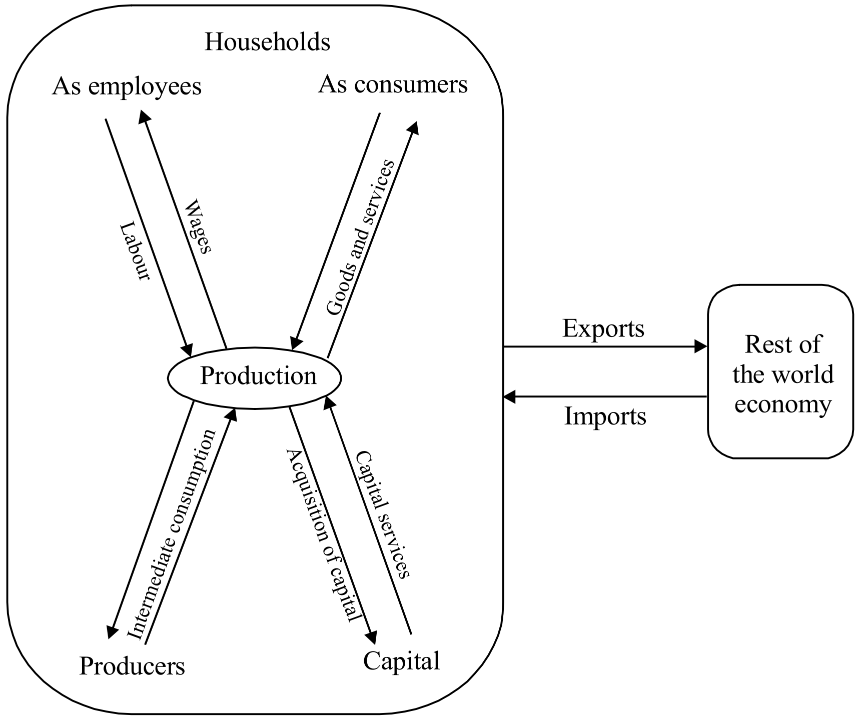
2.21 It is not possible to establish either a simple physical boundary between the economy and the environment or a simple monetary one. It is necessary to look at the sort of flows of interest within the economy, flows backwards and forward between the economy and the environment, and flows within the environment.

Flows within the economy

2.22 The economy can be identified with the collection of activities that use materials, land, energy or human skills to produce goods and services that can be exchanged for money (or for other commodities) including the use of these commodities by their final purchaser. This is sometimes portrayed as "the circular flow of income" whereby income is generated by individuals providing labour to enterprises, receiving compensation for their employment in return, and then spending their income to purchase the goods and services that their labour has helped to create. These flows are shown in the upper left of the large enclosure in Figure 2.1.

2.23 Like many paradigms, this one is somewhat oversimplistic. Some of the goods and services produced in the economy are used to produce other goods and services – as occurs, for example, when cloth is being turned into clothes – and are referred to as intermediate consumption. Some, acquired as capital goods, are used to make other goods and services over a long period, for example, weaving machines. These flows are shown in the lower left of the large enclosure in Figure 2.1.

Figure 2.1. Flows within the economy and with other economies



2.24 No economy actually operates in isolation from the rest of the world. Other economies also supply products, as imports, and absorb some national production in the form of exports. Besides the large enclosure on the left for the entirety of the national economy, Figure 2.1 includes a smaller enclosure on the right for the rest of the world economy, with the flows of imports and exports linking the two.

Flows between the economy and the environment

2.25 The flows of products, whose measurement forms the basis of the SNA, are also measured within the SEEA, though in the SEEA they are recorded in physical terms as well as in monetary ones. The essence of the SEEA, though, is to measure other flows that relate to the interaction of the economy and the environment and to examine how these flows are connected with the flows of products.

2.26 The economy draws inputs from the environment. These consist of natural resources such as mineral deposits, fish and timber and also the ecosystem inputs that are necessary for life, particularly water and oxygen for respiration and combustion. The economy also uses the environment as a sink for unwanted waste material: soil, land, water and air are depositories for solid, liquid and gaseous waste. In the SEEA, all these forms of waste materials are describe collectively as “residuals”. (This word is not ideal but no more acceptable alternative has been found.) Thus Figure 2.1 can be elaborated to include flows of natural resources and ecosystem inputs from the environment to the economy and flows of residuals in the opposite direction.

2.27 Just as there is an interaction between the national economy and the economies of the rest of the world, so there is an interaction between the national economy and the environment of the rest of the world. This includes not only the environment of other countries but the open seas, the upper atmosphere and so on (often referred to as the global commons). Such flows take place when units belonging to the national economy operate abroad. National airlines flying to another country consume oxygen from and discharge residuals to the rest of the world environment. Tourists consume ecosystem inputs and leave residuals behind. Flows between the rest of the world economy and the national environment also take place and need to be registered.

Flows within the environment

2.28 There are flows between that part we may distinguish as being "national" and that part we distinguish as being "the rest of the world". Flows down river courses and air currents are two obvious means of transporting residuals from one natural economy to another. For completeness, these flows within the environment should also be recorded.

2.29 Assembling all these elements, Figure 2.1 can be expanded to Figure 2.2, which also appears in chapter III.

2.30 There are, of course, flows within the economies of the rest of the world and between these and the environment of the rest of the world but, within this Handbook, we assume that it is accounts on a national basis that are of primary interest. Hence, there is no provision for recording these flows within the rest of the world.

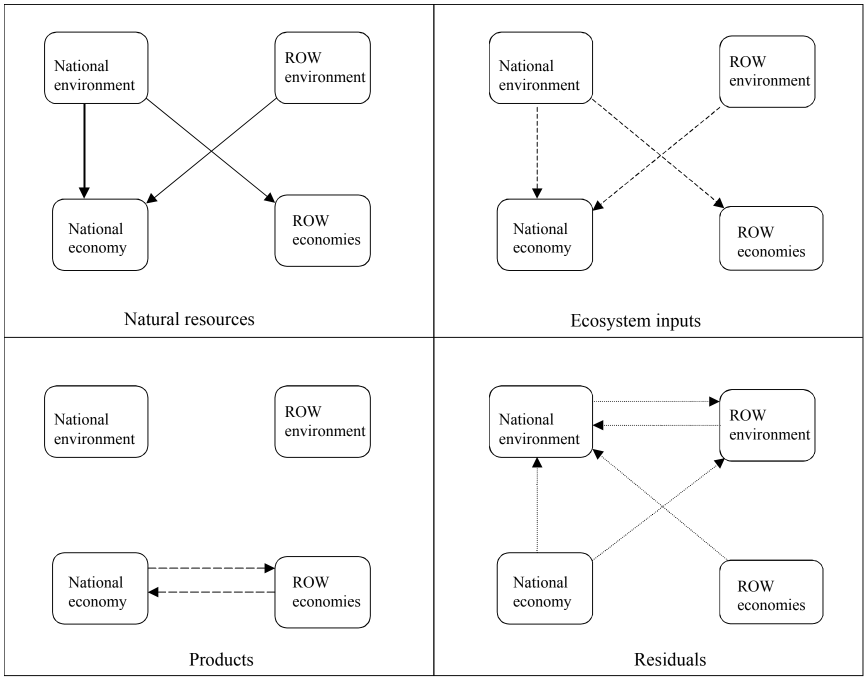
2. The types of flows that are of interest

2.31 Four different types of flows are distinguished in the SEEA. ***Products*** are goods and services produced within the economic sphere and used within it, including flows of goods and services between the national economy and the rest of the world. ***Natural resources*** cover mineral and energy resources, water and biological resources. ***Ecosystem inputs*** cover the water and other natural inputs (for example, nutrients, and carbon dioxide) required by plants and animals for growth, and the oxygen necessary for combustion. ***Residuals*** are the incidental and undesired outputs from the economy that generally have no economic value and may be recycled, stored within the economy or (more usually at present) discharged into the environment. "Residuals" is the single word used to cover solid, liquid and gaseous wastes. Physical flow accounts are created by merging accounts for products, natural resources, ecosystem inputs and residuals, each account being expressed in terms of supply to the economy and use by the economy.

2.32 Although the main flows of interest are between the economy and the environment, we also need to consider whether it is the environment in and above the national territory that receives residuals and whether it is the national economy that generates them. Thus, it is desirable to consider the national economy and the national environment and also the economy and the environment for the rest of the world.

2.33 Flows from the national environment to the national economy consist of resources and ecosystem inputs. The national economy emits residuals to the national environment and to the environment of the rest of the world. In addition, the environment receives residuals from the rest of the world economy and the rest of the world environment. Flows between the two environments are residuals transported by wind and water; the case of residuals going from one economy to the environment of another relates to economic activity taking place abroad, for example, international travel. In addition, products flow between the national economy and the economy of the rest of the world as imports and exports.

Figure 2.2. Flows between the economy and the environment



Note: ROW means rest of the world.

2.34 All physical flows are expressed in physical units. These may be particular to the substance concerned or may, for example, be a more general measure such as tons if aggregation is across a disparate set of substances. Tons are assumed to be the unit of choice in this example as they are in many other cases.

3. Flow accounts for products

2.35 Products are supplied by the economy and also used by it. There is an identity that is central to the SEEA (and in fact to the SNA also) to the effect that when flows of products are measured ex post, total supply and total demand (or use) must exactly balance. New goods and services are supplied in the current period either by resident producers or (as imports) by producers in the rest of the world. Thus:

Total supply = domestic production + imports

These goods and services:

(a) Are used by industries in the course of making other goods and services (intermediate consumption);

(b) Are bought by households to satisfy their wants (household final consumption);

(c) Are bought by Government to satisfy the needs of individual households or of the community at large collectively (government final consumption);

(d) Are bought by industries for use in making other goods and services in future periods (capital formation); or

(e) Leave the economy (as exports) to be used in another country.

Thus:

Total use (demand) = intermediate consumption + household final consumption + government final consumption + capital formation + exports

2.36 In fact, some demand is met not from current production but by using up items that exist in inventories. Traditionally, changes in inventories appear in the total demand equation, appearing as a positive entry when items go into stocks and as a negative entry when they are withdrawn. We thus separate capital formation into two parts: fixed capital formation which relates to the acquisition of capital goods to be used repeatedly in future production (machinery and buildings, for example), and changes in inventories. Thus the composite equation reads:

Domestic production + imports = Intermediate consumption + household final consumption + government final consumption + fixed capital formation + changes in inventories + exports

2.37 This identity must hold for any product or group of products as long as they are measured in units that are consistent for every component. Thus, although the above identity is most familiar to national accountants when expressed in monetary terms, it must also hold when expressed in a common physical unit. Table 2.1 summarizes the information for all activities in SEEAland. Producers supply output and demand intermediate consumption; capital accumulation and consumption both place demand on products; imports are supplied, and exports demanded, by the rest of the world.

Table 2.1. Supply and use table for products

Millions of tons

	Production	Final consumption	Capital formation	Rest of the world	Total for the economy
Supply	551			150	701
Use	442	39	119	101	701

Source: SEEAland data set (abridged version of Tables 3.6 and 3.7).

4. Flow accounts for natural resources

2.38 Natural resources are demanded by the economy but are supplied only by the environment. They may be demanded by producers as intermediate consumption or for final consumption (fuelwood, for example). It is assumed that, even if natural resources are exported in a natural state, they have passed through the economy (for example, transported from the site of origin to a port) and are thus classified as products. An exception is made for natural resources extracted by non-resident units, for example, fish caught by foreign vessels. Capital goods also may contain natural resources but it is unlikely that they will be in a natural, unprocessed state except in the case of inventories. For simplicity, this example assumes zero inventories. A simplified natural resource account is given in Table 2.2.

Table 2.2. Supply and use table for natural resources

Millions of tons

	Production	Final consumption	Capital formation	Rest of the world	Total for the economy	Total for the environment
Supply						264
Use	261	2		1	264	

Source: SEEAland data set (abridged version of Table 3.4).

5. Flow accounts for ecosystem inputs

2.39 The accounts for ecosystem inputs are similar to those for natural resources but supply by the rest of the world and use by the rest of the world occur when units are operating in another territory, for example, when national aircraft are flying in foreign territory. A simplified supply and use table for ecosystem inputs is given in Table 2.3.

Table 2.3. Supply and use table for ecosystem inputs

Millions of tons

	Production	Final consumption	Capital formation	Rest of the world	Total for the economy	Total for the environment
Supply						147
Use	121	24		2	147	

Source: SEEAland data set (abridged version of Table 3.5).

6. Flow accounts for residuals

2.40 Most residuals flow from the economy to the environment. They result from both production and consumption, including the disposal of capital and other durable items acquired in earlier periods. Table 2.4 presents a summary table, also drawing on the example in chapter III. Residuals may be gaseous, liquid or solid and may be released to the air, water or land (including landfill sites). Scrap that is sold for reprocessing is classified not as a residual but as a product. However, some residuals, such as paper and glass products, are recycled without payment to the disposer. This amount is shown as a demand by producers for residuals (7 million tons in this example). The amount of waste put into a landfill site is shown as a demand by capital (land) for residuals (26 million tons here).

2.41 In addition, there are residuals that are transferred out of the domestic environment. Part of these residuals relates to emissions from transport equipment operating outside the domestic environment. These are residuals flowing directly from the national economy to another environment or from another economy to the national environment. The greater part of the flows of residuals between the domestic environment and the environment of the rest of the world, however, are carried by environmental media and thus show as transfers between the domestic environment and another environment or vice versa. The economy generates 415 million tons of residuals but only 42 million tons is either absorbed by the economy or exported. There is thus a net flow of 373 million tons from the economy to the environment.

Table 2.4. Supply and use table for residuals

Millions of tons

	Production	Final consumption	Capital formation	Rest of the world	Total for the economy	Total for the environment
Supply	280	48	73	14	415	
Use	7		26	9	42	373

Source: SEEAland data set (abridged version of Tables 3.8 and 3.9).

7. Summary physical flow accounts

2.42 The four tables above can be assembled into a single table like Table 2.5. Because matter can be neither created nor destroyed, it is possible to calculate a balancing item for each column that shows the balance of accumulation of material in the economic sphere.

2.43 For production, there is no net accumulation other than what producers acquire as capital. The accumulation by consumers relates to products bought this period but not yet used and discarded, that is; consumer durables. Together these two items account for a net accumulation of material in the economy of 89 million tons. Of this, 51 million tons have been imported from abroad, leaving a net impact of 38 million tons drawn into the national economy from the environment.

2.44 Other forms of physical accounts are also possible. Two of these, material flows analysis (MFA) and physical input-output tables (PIOT) are also discussed in chapter III. In addition, chapter III discusses alternative conventions for the measurement of residuals in respect of both biological metabolism and the treatment of waste going to landfill sites.

Table 2.5. Summary physical flow accounts

Millions of tons

	Production	Final consumption	Capital formation	Rest of the world	Total for the economy	Total for the environment
Supply						
Products	551			150	701	
Natural resources						264
Ecosystem inputs						147
Residuals	280	48	73	14	415	
Net accumulation	0	17	72	-51	38	-38
Total supply	**831**	**65**	**145**	**113**	**1154**	**373**
Use						
Products	442	39	119	101	701	
Natural resources	261	2		1	264	
Ecosystem inputs	121	24		2	147	
Residuals	7		26	9	42	373
Total use	**831**	**65**	**145**	**113**	**1154**	**373**

Source: SEEAland data set (abridged version of Table 3.13).

8. Determining suitable classifications

2.45 While the classifications of industries and expenditures used within the SNA cater for a wide range of interests, the focus of the SEEA is on those events and activities that link the environment and the economy. This means, for example, that a finer breakdown may be required for industries that have a significant effect on the environment, and that expenditures on environmental protection need to be classified in terms of their effect on different environmental assets (such as air, water and soil). One topic discussed in detail in chapter III is the use in environmental accounting of appropriate headings from standard classifications for industries and products. The functional classifications of consumption are also covered and new classifications for natural resources, ecosystem inputs and residuals are introduced. More details thereon are given in the annexes to the Handbook.

9. Physical flow accounts, national borders and accounting periods

2.46 Physical flow accounts describe, among other things, how one country interacts physically with the rest of the world. These physical flows represent the direct impacts of the economy of one country on the environmental state of another country. The impacts are caused by three different types of cross-border flows: (a) material flows in connection with international trade, that is, the import and export of products or residuals and the supply of natural resources and ecosystem inputs to units resident in another country; (b) economic activity of one country that takes place outside its own environment, in particular international transport and tourism; and (c) cross-border transfers of residuals. Such transfers may be borne by environmental media such as (polluted) air and surface water but may also result from pollution generated by international transport. It should be noted that international transport may be carried out by residents as well as by non-residents.

2.47 Cross-border residual transfers are important for determining the net total accumulation of residuals in the environment of one country and are particularly relevant for the analysis of environmental degradation problems that are of a non-global nature. The transfers have important implications for the valuation of environmental damages covered in chapter X, since the environmental damages generated by the national economy may differ from damages experienced by the domestic environment.

2.48 Besides these direct physical relationships, the physical flow accounts can be used to analyse the indirect impact of one economy on the environment of other countries. For example, the resources used in, or the residuals arising from, the production of goods and services that are imported to the domestic economy may have indirect effects.

2.49 There can sometimes be a long time lag between an economic activity and the residual emissions reported in the flow accounts by an economic sector. For instance, metal mines can give rise to contamination of freshwater long after the mine is closed. This discontinuity between the time of the economic output and the emission of the residual is also found in landfill sites and, most notoriously, in nuclear waste production. In these cases, accumulation of residual may have to be accounted for as a liability that will generate negative effects in future periods.

C. Introducing matrix style accounts

1. Physical supply and use tables

2.50 A device used throughout this Handbook is a matrix form of presentation for various accounts. This starts with a supply and use table in chapter III, which is elaborated over the course of subsequent chapters. By reading either across the rows or down the columns, one can see the information that would be entered in a double entry system by being recorded twice. The matrix form of presentation thus ensures that the consistency of the accounts is preserved while presenting all the material in a very compact form. In practice, however, when a significant degree of detail is required, the matrix format becomes very large and therefore clumsy to display concisely, especially since it contains a large number of empty cells. For practical presentation of results, an alternative format may be used, especially when information is required in the form of a time series.

2.51 Table 2.6 shows a simple matrix for the supply and use table for products in physical terms. The top row shows how products are used either in the formation of other products (that is, as intermediate consumption), or for consumption, capital formation or exports. The first column shows how the supply of products is made up from domestic production or imports.

2.52 The interest in portraying this information in matrix format is that the total across the first row is equal to the total down the first column (701 million of tons). As the SEEA is elaborated, more rows and columns and more cell entries will be added to the matrix until there is a balance for all the rows and column in the matrix.

Table 2.6. A simple supply and use table for products in physical terms

Millions of tons

	Intermediate consumption 442	Final consumption 39	Capital formation 119	Exports 101
Production 551				
Imports 150				

Source: SEEAland data set.

2.53 We can elaborate this table immediately by adding rows and columns for natural resources, ecosystem inputs and residuals. This is shown in Table 2.7. The first step is to annotate the columns shown in Table 2.6. Then, by expanding the number of rows in the table to match the columns, we can show where residuals arise. We add new rows for natural resources and ecosystem inputs but since there are no flows to these items, we can save space by not including columns for them.

2.54 In order to ensure that the row totals and the column totals for each row and column pair match, an extra column is needed showing the material balance or net accumulation in the economy (if positive) or the environment (if negative). In a more extended table, such as that shown in Table 3.11, information on the rest of the world (ROW) can specify whether the flows concern the rest of the world economy or the rest of the world environment and determine a material balance for each. However, both may be either positive or negative depending on the predominant flow between the national and foreign economy or environment.

Table 2.7. A simple supply and use table for all physical flows

Millions of tons

	Products	Industries	Consumption	Capital	ROW	Residuals	Material balance
Products		Intermediate consumption 442	Consumption 39	Capital formation 119	Exports 101		
Industries	Production 551					From industry 280	
Consumption						From households 48	17
Capital						From capital formation 73	72
ROW	Imports 150					Residuals generated by non-residents 6	-46
Natural resources		To industry 261	To households 2		To ROW 1		-264
Ecosystem inputs		To industry 121	To households 24		To ROW 2		-147
Residuals		To industry 7		Waste to landfill sites 26	To ROW 6		368

Source: SEEAland data set (abridged version of Table 3.11).

2. Monetary supply and use tables

2.55 The structure of the supply and use tables in monetary terms as described in the SNA is essentially similar to that shown in Table 2.6. It relates to products only since none of the natural resources, ecosystem inputs or residuals carry monetary values. It is thus a moot point whether they appear with zero value or not at all.

2.56 The standard SNA supply and use matrix can be adapted for use in environmental accounting by employing the same classifications as described for the physical supply and use tables, depending on the Central Product Classification (CPC) and the International Standard Industrial Classification of All Economic Activities (ISIC) in both cases. Classifications of government and household consumption are also compatible, each system drawing on the Classification of the Functions of Government (COFOG) and the Classification of Individual Consumption According to Purpose (COICOP). Despite these similarities, there are a number of important differences to be noted.

Value added

2.57 The first difference is that the monetary accounts resolve the supply/use identity by means of a term entered in the supply part of the table referred to as value added. This is the excess of the returns a producer receives over the costs he incurs in terms of inputs of products (intermediate consumption). From this amount, he pays his labour force and retains an element of operating surplus to cover his use of all sorts of capital: produced capital such as machines and buildings, financial capital such as bank loans and shareholders equity and, in fact, the natural resources that he uses up in the course of production. The attribution of value added to these different sorts of capital is discussed below and at length in chapter VII. It is sufficient for the moment to note that value added constitutes the balancing item with respect to the supply and use identity in monetary terms and is introduced to explain the excess of the value of outputs over the cost of inputs, whereas in physical terms, the generation of residuals may be thought to constitute the balancing item, explaining the shortfall of outputs compared with inputs.

Services

2.58 For industrialized economies, the monetary tables are dominated by the role of services; in physical terms, although services absorb products, in general they do not supply any because their output is weightless. (Some exceptions do exist, such as the food and drink supplied by restaurants and computer software which is delivered through physical media; but the weight of these items is very small compared with the weight of goods in the economy.) Government consumption also consists of services, hence it is less conspicuous in physical tables than in monetary ones.

2.59 This comparison carries over to the question of "price per kilo". Many of the items that are most important in physical flows are building materials which tend to have rather low unit prices, whereas electronic equipment is relatively low in volume terms but high in value terms because it has a much higher value-to-weight ratio. Thus, whereas in physical tables it is the weight of materials that determines their share of the total, in monetary tables it is a combination of the volume and the unit price. The price differential conveys information about relative scarcity. The scarcer the product, relative to the demand for it, the higher the price. Anything that is so abundant as not to be scarce has no monetary value.

Prices

2.60 It is appealing to think that a set of monetary supply and use tables is simply a physical set of tables in which each row element is multiplied by the appropriate unit price. However, statistical life is seldom so simple. The same good sold in different outlets may often carry a different price, a discount outlet being noticeably cheaper than a fashionable department store. Here the reactions of the price statistician and the national accountant are different. For the price statistician, if the goods are physically identical, then the difference between the amount paid in the discount store and that paid in the department store is simply a price difference. The national accountant disagrees, however. The department store provides a higher level of service than the discount store and thus the higher price is really due to the fact that it includes the costs reflecting a more congenial and convenient location, staff trained to provide informed information on similar brands and so on. To the national accountant, goods in different outlets and at different prices are different products even if their physical characteristics are identical because they come "packaged" with different amounts of services.

2.61 The difference between the value of a good as it leaves the factory and the price the consumer pays is due to two elements. The first of these is the "service margin" just described. The second is the level of tax the consumer must pay at the time of purchase. The tax may be in the form of a value-added tax (VAT), for example, or an excise tax payable on such products as cigarettes, alcoholic beverages and petrol. The value of the good as it leaves the factory is described as being "at basic prices"; the value when the margins and taxes have been added is described as being "at market prices".

2.62 The value added across all production activities constitutes a measure of gross domestic product (GDP) at basic prices. For most purposes, however, GDP is usually quoted at market prices. Following the discussion above on the difference between basic prices and market prices, this means that it is necessary to add to GDP at basic prices a measure of the taxes paid by purchasers at the point of purchase. The "service margins" that form part of the difference between basic prices and market prices on particular goods are grouped together to form an industrial activity of their own (wholesale and retail trade) and so are already included in GDP at basic prices.

2.63 A question then arises about the price valuation used to achieve a balance between the supply and use tables. In fact, a balance at either price can be achieved and generally both types of balances will be achieved. A balance at market prices is usually the easiest to achieve. Items on the use side of the account are most naturally collected in market prices since these are the prices the consumer knows. Items on the supply side can be converted to market prices by adding the appropriate level of service margin and tax for each type of product.

2.64 The alternative is to leave the supply side in basic prices and to reduce the use side to those same basic prices by creating separate estimates for service margins and taxes. This is often complicated. Not only do different outlets carry different service margins, but different customers may experience different tax rates. For example, businesses may be able to reclaim the VAT on some or all of their purchases, although households seldom can.

2.65 Nor is the situation any easier with services. One kilowatt-hour of electricity is identical to any other but the prices charged to different classes of customer are quite different and may depend not only on whether those customers are businesses or private persons but also on the level of total usage of electricity or on the time of year. Similar problems of determining prices arise for many services, telecommunications and issuance of airline tickets being obvious examples.

2.66 The environmental statistician does not have to know the exact methodology used to circumvent these measurement problems but it is important that he or she have a broad grasp of the difference between basic prices and market prices and know which applies to the monetary data being used. Monetary flows at basic prices have a more homogeneous unit price and are thus appropriate when used in conjunction with physical flows. On the other hand, they may not always exist at the level of detail needed or at the frequency required, since for many sorts of economic analysis, data at a higher level of aggregation or at market prices may be adequate.

The SNA supply and use table

2.67 Table 2.8 shows the simple monetary supply and use table that corresponds to Table 2.6. Figures in millions of tons are replaced by data in billions of currency units. Two new items are added to the first column: trade and transport margins, and taxes less subsidies on products. In total, trade and transport margins are shown as zero but the additions to the valuations of individual products is significant when disaggregation is effected. The total of the first column is 1,719.4 billion currency units. This represents total supply at market prices and is also the total of the first row.

2.68 The second column contains a new item, value added. The size of value added is determined precisely in order to ensure that the sum for the second column is exactly the same as the sum for the second row. The total of 1,286.4 billion currency units is the value of national production at basic prices.

Table 2.8. A simple supply and use table in monetary terms

Billions of currency units

	Intermediate consumption 664.0	Final consumption 506.4	Capital formation 146.0	Exports 403.0
Production 1 286.4				
Trade and transport margins				
Taxes less subsidies on products 70.0				
Imports 363.0				
	Value added 622.4			

Source: SEEAland data set.

3. A hybrid supply and use table

2.69 The SEEA makes extensive use of a particular form of matrix accounting which includes in the same table monetary flows relating to products and physical flows relating to natural resources, ecosystem inputs and residual generation. Such tables are referred to as "hybrid" tables because they contain data in different units – tons and currency units, in this case. However, even though the units are mixed, the different data sets are presented according to common classifications and definitions. Any form of national accounts matrix can exist in a hybrid form; hence there can be hybrid supply and use tables, hybrid input-output tables and hybrid social accounting matrices.

2.70 A hybrid supply and use table can be formed by superimposing Table 2.8 on the products part of Table 2.7 to give the composite table shown in Table 2.9. The top left part of the table (that enclosed by the boldface dotted margin) shows product flows in both physical and monetary terms. The rest of the table refers to flows of natural resources, ecosystem inputs and residuals. These are observed in physical terms only. Hybrid accounts occur frequently throughout this Handbook, but Table 2.9 is the only example where the physical and monetary data in respect of products are shown together. This is because in practice a breakdown by product and industry is used and presenting two sets of figures throughout the table becomes clumsy and space consuming. Further, much of the analytical interest lies in linking the physical environmental flows with monetary economic flows. Thus, the hybrid account in its usual format contains monetary data only in respect of products, though it should be remembered that the corresponding physical flows exist even if these are not shown explicitly.

2.71 Further sub-matrices of the same dimensions can be calculated showing, for example, the relationship between residual generation from industry and the corresponding inputs in either physical or monetary terms. Sometimes these coefficients are available from external sources and are used to construct the residuals sub-matrix; sometimes the information about residuals is available separately and the coefficients are derived once the other sub-matrices are complete. Section B.4 of chapter IV on energy accounts and carbon dioxide emissions describes this situation in greater detail.

Table 2.9. A simple hybrid supply and use table (SEEAland data set)

		Economy							Residuals			
		1. Products		2. Industries	3. Consumption	4. Capital	5. ROW (products)	*Total economy*	10. National destination	11. ROW destination	9. Material balance	Total use
		Physical	*Monetary*									
Economy	1. Products Physical *Monetary*			Products used by industry 442 *664*	Products used for consumption 39 *506*	Products used for capital 119 *146*	Products used by ROW (exports) 101 *403*	*1 719*			0	701
	2. Industries	Products supplied by industry 551	*1 356*					*1 356*	Residuals generated by industry 275	Residuals generated by industry in ROW 5	0	831
	3. Consumption								Residuals generated by consumption 47	Residuals generated by consumption in ROW 1	Net material accumulation by consumption 17	65
	4. Capital								Residuals generated by capital 73		Net material accumulation by capital 72	145
	5. ROW (products)	Products supplied by ROW (imports) 150	*363*					*363*	Residuals generated by non-residents 6		Net material accumulation by ROW economy - 52	104
	Value added			*692*				*692*				
	Total economy		*1 719*	*1 356*								
Natural resources	6. National environment			Natural resources supplied to industry 256	Natural resources supplied to consumption 1		Natural resources extracted by ROW 1				Net accumulation of natural resources in the national environment - 258	0
	7. ROW origin			Natural resources supplied to industry 5	Natural resources supplied to consumption 1						Net accumulation of natural resources in the ROW - 6	0
Ecosystem inputs	8. National environment			Ecosystem inputs to industry 118	Ecosystem inputs to consumption 23		Ecosystem inputs to ROW economy 2				Net accumulation of ecosystem inputs in the national environment - 143	0
	9. ROW origin			Ecosystem inputs to industry 3	Ecosystem inputs to consumption 1						Net accumulation of ecosystem inputs in the ROW - 4	0
Residuals	10. National origin			Residuals reabsorbed by production 7		Waste to landfill sites 26				Cross boundary residual outflows 4	Net accumulation of residuals in the national environment 373	409
	11. ROW origin								Cross boundary residual inflows 8		Net accumulation of residuals in the ROW 1	9
	Total supply	701		831	65	145	104		409	9	0	2 264

Note: Monetary data (in italics) is in billions of currency units.

Physical data (non-in italic) is in millions of tons.

2.72 Another point to note in connection with this table is that it can be constructed not just for all natural resource and ecosystem inputs and residual outputs, but also to focus the attention on only a limited number of inputs and residuals, possibly only one input and one residual. A common case in point is the generation of carbon dioxide from fossil fuel combustion. A particular instance of this is described in section B.5 of chapter IV on emissions accounts.

4. Introduction of the term "NAMEA"

2.73 The concept of a matrix presentation of monetary accounts augmented by the input of natural resources and ecosystem inputs and residual outputs in physical terms has been used extensively by Statistics Netherlands over several years. They used the acronym NAMEA for such a table, (short for National Accounting Matrix including Environmental Accounts) and this term has entered into common parlance as shorthand for any such augmented matrix. In practice, most NAMEAs that have been compiled so far are hybrid supply and use tables but in concept any monetary table which has been "hybridized" in this way can be called a NAMEA. Thus, the term NAMEA may apply to a table in which the monetary part corresponds to a supply and use table, to an input-output table or to a full social accounting matrix. This Handbook, however, seldom uses the term NAMEA in order to be able to indicate whether the hybrid tables under discussion are supply and use tables, input-output tables, matrices containing all national accounts flows or full national accounting matrices containing stock information also.

5. Supply and use and input-output tables

2.74 Even the simple supply and use tables given above have separate rows and columns for products and industries. It is products that are used for intermediate consumption, capital formation or exports but it is industries that use intermediate consumption, imports and environmental resources and generate both value added and residuals.

2.75 A number of analyses depend on a matrix where the same classification is used for supply and use. It is thus necessary to collapse the product and industry dimensions so that the matrix presentation is simplified to compromise a single row and column. Such a table is an input-output table.

2.76 The supply and use table is emphasized in this handbook and in the SNA because it corresponds to data as observed. Many industries manufacture more than one product and it is impracticable to ask them to separate all their costs and value added into the parts pertaining to each product. However, what we cannot obtain by observation, we can construct analytically. The means of doing this are discussed in chapter IV and the resulting table is presented in Table 4.14.

2.77 The advantage of the input-output format is derived from the analytical uses of the table. We can, for instance, calculate the implicit contribution of electricity to all products by tracing and cumulating the input of electricity in every stage of the production process. If we consider electricity generated by the combustion of fossil fuel, we can calculate approximately how much for fossil fuel is needed for any product. Further, if we know, for example, that 60 per cent of electricity use comes from national production and 40 per cent is imported, we can start to calculate the approximate total demand for fossil fuel and not just that used for electricity-generation within the national economy.

D. SNA flow accounts

2.78 As noted before, the SEEA was conceived as a satellite account to the SNA. This means that the format of the accounts and the conventions underlying them are heavily influenced by those of the SNA. Some understanding of the SNA is desirable in order to fully understand the implications of the SEEA.

For the physical flow accounts and the establishment of hybrid supply and use tables described in the preceding sections, an understanding of the goods and services account which reconciles production with final expenditure is sufficient. However, while this account describes the final outcome of economic activity in a period, it does not explain how the income generated by production becomes available to different types of units in the economy and how they decide to spend or invest this income. To understand this, it is necessary to consider the "sequence of accounts" of the SNA which explains the steps whereby income, once generated, is distributed, redistributed and finally used. With this as background, we can examine in depth particular parts of the system that are interesting from an environmental perspective. This is the "internal satellite account" aspect of the SEEA.

1. The SNA sequence of (current) accounts

2.79 Each step of income distribution, redistribution and use is described in a separate account. Each account has a name and leads to a balancing item which ensures that the sources and uses of funds are equal. These balancing items are of analytical interest in themselves and are often quoted in isolation from the underling sequence of accounts. Domestic product and national income are two such balancing items.

2.80 It is the balancing items that link successive accounts since the item which is the last entry on the uses side of one account is the first item on the sources side of the next account in sequence. The following description of the accounts focuses on the establishment of these balancing items.

2.81 The identity described in connection with Table 2.8 whereby ***value added*** is defined as the balancing item between production and intermediate consumption, is described in the SNA as the production account. Value added across all production activities constitutes a measure of ***gross domestic product*** (GDP) at basic prices. For most purposes, however, GDP is usually quoted at market prices. Again, as noted in connection with discussion on Table 2.8, it is necessary to add to GDP at basic prices a measure of the taxes paid by purchasers at the point of purchase less any subsidies received at that point. These taxes and subsides are recorded in the generation of income account.

2.82 The next account is the account for the distribution of primary income. This shows how value added is distributed, part to the employees of production activities and some to the owners of financial capital and land as payments of rent, interest and dividends, collectively called property income. Value added adjusted for property income yields ***primary income***. For the economy as a whole, there may be property income and compensation of employees payable to, and receivable from, the rest of the world. Taking these into account yields ***national income***.

2.83 Redistributing income in the next stage is achieved by means of transfers. These are payments made without a quid pro quo, or in other words, payments made that are not related to the exchange of a good, service or asset. The largest type of transfer payment is taxes on income, wealth etc., that is, current taxes other than those related to production and consumption. The secondary distribution of income account shows how primary income adjusted for payments and receipts of transfers gives ***disposable income.***

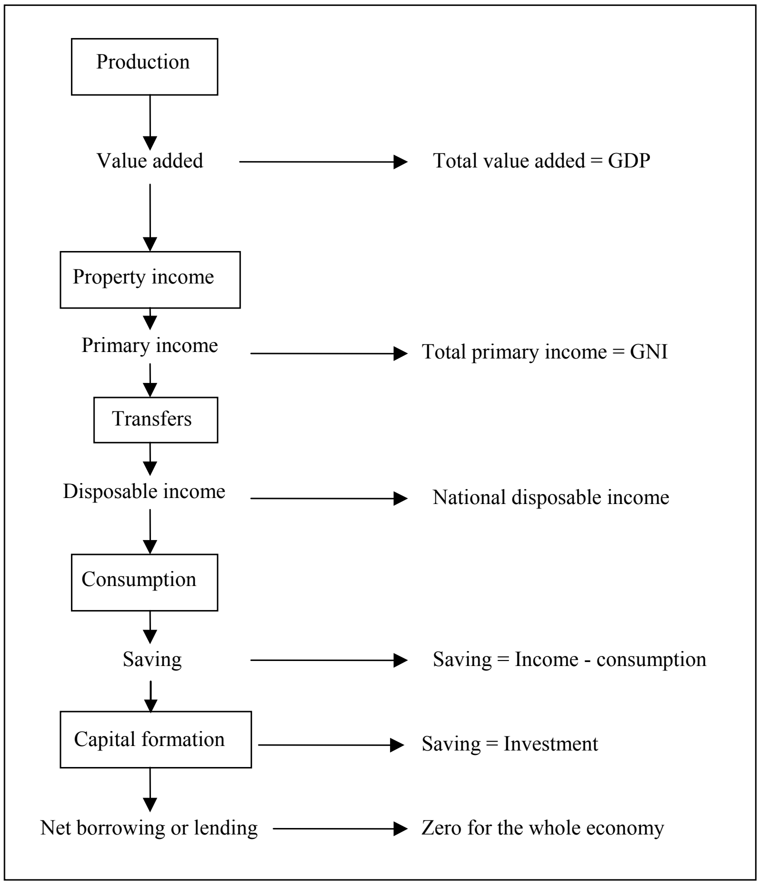
2.84 Disposable income can only be spent or saved. The next account, the use of disposable income account, shows how ***saving*** is derived by deducting current consumption from disposable income.

2.85 Income that is saved is used for either the acquisition of fixed capital or financial assets (loosely called investment). Any surplus is lent to other units; any deficit is made up by borrowing. These transactions are shown in the capital account.

2.86 The financial account shows how ***net borrowing and lending*** are reconciled across the economy as a whole since – and this includes transactions with the rest of the world – one person's net borrowing has to be another's net lending and in total they must sum to zero.

2.87 This very abbreviated discussion is presented schematically in Figure 2.3. Further details can be found either in the 1993 SNA or in other national accounts material.

Figure 2.3. Schematic view of the SNA sequence of accounts



2. Relevance of the accounts in the SEEA

2.88 There are at least three aspects of these accounts that are relevant to the full accounting system of the SEEA, namely:

(a) Payments of taxes, since the impact and effectiveness of eco-taxes are clearly of concern for environmental policy;

(b) Establishment of property rights and the payments of property income, some of which are in respect of environmental assets;

(c) Relationship among income, consumption, saving and investment towards the end of the sequence of accounts, which cuts straight to the heart of the discussion about sustainable levels of income and wealth.

2.89 In order to explore these aspects fully, however, it is necessary to examine the role of "sectors" in the accounts. Without accounts for sectors, it is not possible, for example, to portray the impact of taxes on the accounts of businesses, households and government or to compare households with businesses with respect to their relevant contributions to, and their difficulties arising from environmental problems.

3. The sectors of the national accounts

2.90 Each transaction in the accounts involves two parties, the one who makes a payment and the one who receives it. All the resident units in the economy can be classified into one of four groups. These groups have significantly different purposes in the economy, different main sources of income and different patterns of expenditure.

2.91 ***Financial and non-financial enterprises*** (businesses in a non-technical term) are involved in production and in capital formation (investment), required to permit them to continue production in the future.

2.92 ***Households*** provide labour to enterprises and government and spend the money they earn on the goods and services produced in the form of current consumption. The main capital formation of households is the purchase of houses.

2.93 ***Government*** raises taxes from both enterprises and households and uses the revenue generated to provide services to individual households, the community at large and enterprises alike. Government also undertakes capital formation.

2.94 There is another small sector relating to ***non-profit institutions serving households***. These cover, for example, charities providing food and shelter to the needy and educational services. It is probable that they affect the environment mainly through raising public awareness of environmental problems but there may be some environmental remedial action undertaken by such groups.

2.95 Lastly, non-resident units that interact with the national economy can be grouped together into a de facto fifth sector, called the ***rest of the world***. Balance of payments accounts are in fact a set of accounts consistent with the SNA for the rest of the world transactions only.

2.96 Not all developing countries have yet implemented sector accounts though it is hoped that with the introduction of the 1993 SNA more of them will do so. Their importance from the point of view of monitoring how the government functions and implements (or fails to implement) policy can hardly be exaggerated. Furthermore, the responsibilities of the ownership of natural resources can be monitored only with the aid of sector accounts which allow the owners and users of these resources and the transactions relating to them to be identified.

4. A full accounting matrix

2.97 A supply and use table can be extended to show all these flow accounts in matrix format also. Such a matrix is called a national accounting matrix. An example of such a matrix is given in Table 2.10.

2.98 The conventions for this matrix are the same as those for previous tables examined. There is a match in coverage between the rows and columns, and the total value for each row matches the total of the corresponding column of elements of the supply side. Each row consists of the elements of the use side of an account and the corresponding column consists of the elements of the supply side. Balancing items ensure this equality and are recorded at the intersection of the column for one account and the row for the succeeding account. Transactions that redistribute income or saving are shown on the diagonal element of the account concerned. They do not (here) affect the total level of the successive balancing items but do affect how the income is allocated once the redistribution is complete. Illustrative arrows have been added to the central part of Table 2.10 to illustrate the sequence of accounts.

Table 2.10. A schematic national accounts matrix

		Goods and services (products)	Production (industries)	Distribution of primary income account	Secondary distribution of income account	Use of income account	Capital account	Financial account	Rest of the world
		1	2	3	4	5	6	7	8
Goods and services (products)	1		Intermediate consumption			Final consumption	Capital formation		Exports
Production (industries)	2	Output							
Distribution of primary income account	3		Value added	Property income					
Secondary distribution of income account	4			Balance of primary income	Current transfers				
Use of income account	5				Disposable income				
Capital account	6					Saving	Capital transfers		
Financial account	7						Net lending or borrowing	Acquisition and disposal of financial assets	
Rest of the world	8	Imports						Net lending to or borrowing from the ROW	

2.99 Table 2.10 is simply a skeleton matrix. In practice, the rows and columns are disaggregated according to the transactions of interest. In addition, more transactions with the rest of the world will be recorded. For example, property income payments from the rest of the world will appear in the row for distribution of primary income account and in the column for the rest of the world, and the payments to the rest of the world in the cell that is in the row for the rest of the world and in the column for distribution of primary income. Such items will affect the level of balancing items in the account where they appear.

2.100 Just as the monetary supply and use matrix can be portrayed in hybrid form by the addition of columns for residual generation and rows for the use of environmental flows, so the national accounts matrix can be similarly extended. (It is this conception of the hybrid account that gave rise to the acronym NAMEA, indicating, as mentioned above, a national accounting matrix including environmental accounts.) Table 6.5 represents a hybrid national accounts matrix which appends the environmental information to the matrix in Table 2.10 and also shows the more complex recording for the rest of the world account indicated in the previous paragraph.

5. Identifying environmental transactions within the accounts

2.101 With an understanding of the way in which the SNA treats payments between sectors, it is possible to consider how to identify those of interest from the environmental point of view. One such case concerns environmental taxes. Another concerns the acquisition of property rights over, and payments to make use of, environmental assets. These are discussed briefly below.

Environmental taxes

2.102 The first task is to determine which categories of payments to government described in government accounts as taxes should, or could, be considered "environmental" in nature. The guiding principle, agreed by a number of international agencies, is that an environmental tax is one whose tax base is a physical unit (or proxy of it) that has a proved specific negative impact on the environment.

2.103 The next task is to decide whether something appearing in the government accounts as a tax will be treated as a tax in the SNA or, perhaps, as a fee for a service. Even if the SNA treats the payment as a tax, there is still further identification necessary. Taxes appear under one of four headings in the SNA. They are associated with products, with production, with income or with the ownership of capital. Taxes on products and production are recorded in the production account and generation of income account. If there are any subsidies with environmental impacts given to producers or in respect of products, these will be recorded in the same accounts.

2.104 Taxes on income are one item within the current transfers included in the secondary distribution of income account. Taxes on capital are recorded as one item in capital transfers in the capital account. By identifying the location of environmental taxes within the system, the impact on national income and on subsequent balancing items can also be investigated.

2.105 Chapter IV provides a detailed discussion of the identification and quantification of environmental taxes.

Property rights and property income

2.106 The item for property income in the distribution of primary income account consists of actual payments made or due to the owner of an asset by a different user. Most property income takes the form of interest and dividends in respect of financial assets. However, rent on land is also included here as is rent paid in respect of other natural resources. The issue of the implicit value of resource rent when an asset is used by the owner is discussed in section F below.

2.107 Property income in general and rent in particular relate to payments that fall due on an annual basis or more frequently. Increasingly, there is interest in the practice of securing the right to use an asset for an extended period of time or even in perpetuity. Such acquisitions come under the heading of property rights. Of particular interest in the environmental context are rights to use environmental media such as the entitlement to emit gases to the air conferred by emissions permits and the right to extract natural resources conferred by fishing quotas.

2.108 This is an area that was explored during the revision of the SNA completed in 1993. The opportunities to recognize and include transactions in property rights are much greater than in the earlier version of the SNA. New types of contracts continue to emerge and there is still some discussion about how these should be handled within the SNA. Chapter VI discusses how to record longer-term permits.

E. A set of accounts for environmental protection expenditure

2.109 The previous section showed how a subset of a particular transaction can be located and measured within the system. Often, though, the subject of an internal satellite account will be broader than this and the goal will be rather to identify all transactions within the system that have a bearing on the topic of interest. Chapter V discusses how a set of such accounts might be established, addressesing environmental protection expenditure and resource management. However, since most experience to date has been with environmental protection expenditure, it is briefly described here also, as an example of these sorts of internal satellite accounts.

2.110 The environmental protection accounts aim to measure what is being done to protect the environment, in terms of environmental protection and management activities, products to protect the environment and expenditure on these goods and services. These items are already covered within the main SNA accounts but reformatting and disaggregation are required to highlight them and to present specifically environment-related economic accounts. The sorts of environmental protection activities to be covered, such as investment in clean technologies or restoring the environment, are defined in the Classification of Environmental Protection Activities and Expenditure (CEPA 2000) (see annex V).

2.111 There are two main aspects of compiling a set of environmental protection expenditure accounts. The first entails adapting the principles for determining a supply and use table to a specific range of activities and products; the second entails investigating the level of national expenditure on environmental protection and examining how this is financed.

1. Compiling a supply and use table

Identifying the activities of interest

2.112 The starting point is to consider which activities are typical for environmental protection. Four main groups of activities are considered: those that are specifically intended to ameliorate the environment, those whose environmental benefits are largely incidental to their main function, those directed to management and exploitation of natural resources and those aimed at minimizing natural hazards. The extended classification of such activities is examined in depth in section C of chapter V.

Identifying the producers

2.113 The next consideration is to determine whether these activities are undertaken by units whose main activity is providing environmental protection services or by non-specialist producers as secondary activities. In both cases, these activities are described as "external" services because they are provided by one enterprise to a user external to that enterprise – either another enterprise, government or households. In addition, some enterprises may undertake environmental protection activities on their own account and these in-house or ancillary activities are called "internal".

Ancillary activity

2.114 One feature of satellite accounts like this is that an activity that is treated in the SNA as ancillary (that is, not separately shown) is externalized in the satellite account. Thus, to take a very simple example, consider a producer employing a cleaner and cleaning materials, instead of aggregating them without distinction with other compensation of employees and intermediate consumption, they are treated as the components of a production account for the activity of cleaning and the whole of the value of this cleaning activity is then treated as intermediate consumption by that producer.

2.115 This process increases both output and intermediate consumption but since they each increase by the same amount, the value of value added, and thus GDP, is not affected. The fact that it does permit cleaning activities across the whole economy to be compared regardless of whether they are performed on own account or purchased, is the rationale for the alternative treatment of ancillary activity.

Identifying the products of interest

2.116 The next requirement is to determine which goods and services are typically used for environmental protection. Clearly, environmental protection services are included. It is also common to include "cleaner and connected products" which, though they may not be acquired only for their environmental effects, do produce environmental benefits at the same time. The purchase of cars with catalytic converters is one such example. Together, these goods and services are thought of as being supplied by an environmental goods and services industry, sometimes referred to in short as the "environmental industry". The identification of this group of producers which cuts across conventional classifications of industries and products is also discussed in section C of chapter V.

2.117 Clean products are not necessarily valued at their full cost but only as the difference between the "clean" version and a "dirty" version. The "cleaning" is thus an extra cost recorded in effect as another type of margin and the "dirty" product in the same way as any non-environmental-related product.

Identifying the users of the products

2.118 Some users are obvious from the nature of the products they employ. Other users are more difficult to identify. There are no built-in identities, as there are in the accounts for the whole economy, to help cross-check the level of the various components. Rather, looking at estimates from both the supply and use side in order to ensure a total coverage of all relevant items is intrinsic to the nature of building this sort of satellite account. Information on the use of environmental products may come from a wide variety of sources – some used in the regular compilation of national accounts and some more specialized.

Assembling the supply and use table

2.119 Once all these sets of transactions have been identified, they can be assembled into a supply and use table, as indicated in brief in Table 2.11. The more detailed table is shown as Table 5.6.

Table 2.11. Supply and use table for environmental protection services

Millions of currency units

	Government services	Specialist services	Ancillary services	Cleaner and connected products	Total
Output at basic prices	3 000	6 500	4 000	1 000	14 500
Imports				50	50
Taxes and margins	120	150		150	420
Total supply at market prices	**3 120**	**6 650**	**4 000**	**1 200**	**14 970**
Intermediate consumption	0	4 900	4 000	600	9 500
Government consumption	1 800				1 800
Household consumption	1 320	1 650		600	3 570
Capital formation		100			100
Total use at market prices	**3 120**	**6 650**	**4 000**	**1 200**	**14 970**

Source: SEEAland data set.

2. National expenditure on environmental protection

2.120 The total use of environmental protection products may not be identical to the amount of national resources devoted to environmental protection. There may, for example, be subsidies given by government to producers to pursue more environmentally friendly practices. There may be grants received from abroad to assist in ameliorating environmental damage. Households may make transfers to non-profit institutions with environmental goals. Governments may use environmental taxes to fund particular environmental activities.

2.121 For these reasons, a set of complementary tables can be compiled that show the total level of national expenditure on environmental protection when these designated transfers have been taken into account. In addition, a distinction can be made between those units providing the financing and those undertaking the expenditure.

2.122 Tables that elaborate these aspects of environmental protection are developed in section D of chapter V. They are based on proposals given in chapter XXI of the SNA and draw on transactions included throughout the sequence of accounts of the SNA.

F. Stocks of assets in the SEEA

2.123 Section D gave an outline of the SNA flow accounts. These articulate the relationship between production and consumption and show how the identity between them is brought about via the mechanism of income. Accumulation involves stocks of assets as well as flows. The present section discusses the role of assets in the SNA and the consequences for environmental assets.

1. Defining assets

2.124 In the SNA, an asset is defined as an entity (a) over which ownership rights are enforced by institutional units, individually or collectively and (b) from which economic benefits may be derived by their owners from holding them or using them over a period of time. This definition is wide enough to cover many assets of an environmental character, for example, cultivated biological resources, some non-cultivated biological resources such as fish stocks and natural forests, and a number of naturally occurring entities such as land and mineral deposits. However, it is not exhaustive as far as environmental resources are concerned. Land too remote or poor, fish stocks of no interest to mankind for food, and mineral deposits whose profitability is uncertain are excluded either because no economic benefit is involved or because no ownership is enforced (or possibly for both reasons).

2.125 For the SEEA, the asset boundary of the SNA is expanded to cover all environmental entities that are of interest and measurable. The environmental assets covered by the SEEA are grouped into the following broad categories:

- Natural resources:
  - Mineral and energy resources;
  - Soil resources;
  - Water resources;
  - Biological resources;
- Land and associated surface water;
- Ecosystems.

2. An asset account in physical terms

2.126 For an asset whose stock we can measure in physical terms, we start with the simplest possible identity. The stock of the asset at the end of the year is equal to the stock at the start of the year adjusted for the changes that have taken place during the year. These changes may be additions or deductions and will be of somewhat different natures for different assets. They will reflect the intervention of people, for example, the slaughtering of animals and the harvesting of timber, and natural environmental processes such as the birth and death of wild animals. These changes may be regular, as in the above examples, or very irregular, such as losses caused by natural disasters, hurricanes, earthquakes, floods and so on. Table 2.12 presents an illustrative asset account.

Table 2.12. Illustrative physical asset account

Opening stock
Increases during the year
New discoveries of minerals
Natural growth of plants and animals
Land reclamation
Decreases during the year
Extraction of minerals
Soil erosion
Loss of capacity of reservoirs due to silting
Harvesting of plants and animals
Natural death of plants and animals
Loss of animals due to drought
Closing stock

2.127 Formally, we may further subdivide the increases and decreases in stock levels into those which are due to economic impacts and those that are not. Economic impacts cover decisions by economic agents to harvest or extract resources, residuals generated by the economy and so on. Non-economic changes include natural growth and the effects of natural disasters. The boundary is not absolute. Some so-called natural disasters can be traced to human actions, for example, floods whose impacts are exacerbated by human activity. There may be different opinions about whether to record the discovery of new mineral deposits as the result of human activity or not. The decision what to treat as "economic" and what as "natural" may be driven by the type of analysis required. For the moment, we suppose that such a division can be made without pursuing the exact demarcation further.

3. Asset accounts in the SNA

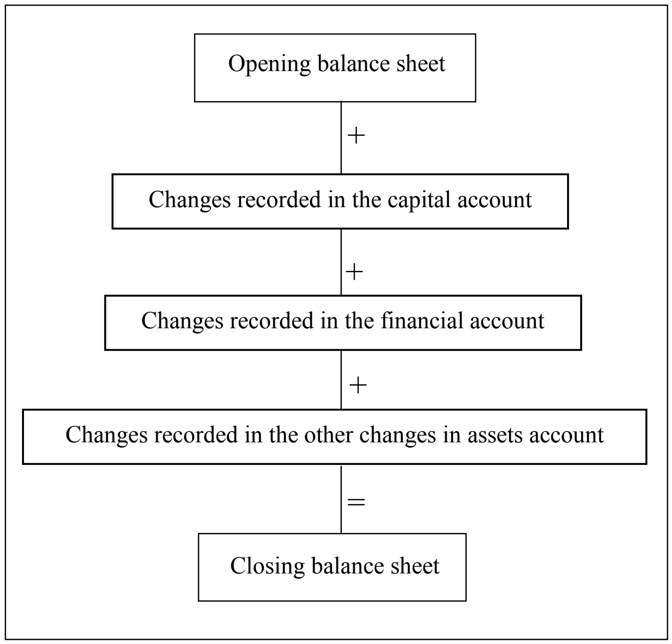
2.128 There are two accounts in the SNA other than those in the sequence of accounts discussed in section D that are important for measuring stocks of assets. The first is the balance sheet which is typically compiled at the start and end of an accounting period, usually taken to be a year. The second is the other changes in assets accounts. This covers flows that are not transactions, that is, events that occur outside the marketplace covered by the sequence of accounts. Many of the changes in environmental assets are recorded here, such as discoveries of subsoil deposits and natural growth of non-cultivated assets. This is also the place where the effects of natural disasters and price changes are recorded.

2.129 The term "accumulation accounts" is used in the SNA to cover both these accounts and also the capital and financial account. Their linkage is presented in Figure 2.4. All the changes in the value of assets between the opening and closing balance sheets must appear in the capital account, the financial account or the other changes in assets account. This relationship emphasizes the role of the last account as a sort of catch-all for anything not previously recorded.

2.130 The entries recorded in the capital account cover the acquisition and disposal of non-financial assets. All non-financial assets are covered, including those environmental assets that fall within the

SNA asset boundary. This includes purchases of land, for example, but inasmuch as land is always recorded as having been exchanged between resident units, these sales and purchases will cancel out for the economy as a whole. They will show up, however, at the level of individual sectors.

Figure 2.4. Schematic view of the SNA accumulation accounts



2.131 The concept of the set of accumulation accounts is very similar to that of an asset account but they are compiled for an economic unit or sector, covering all the assets they own, rather than for asset types.

4. Placing a value on assets

2.132 The SNA recommends that market prices be used wherever practicable to place a value on an asset. Unfortunately, this is not always possible. Some purpose-built produced assets may not have a market value other than the cost of construction, and the market in second-hand assets is frequently too shallow to provide realistic market prices. In such cases, alternative methods of valuation have to be sought. One approach is to call on economic theory which states that at any point in its life, the value of an asset should be equal to the value of future income streams to be provided by the asset discounted to the present period. This principle can be applied to produced assets and also to environmental assets. It is an important means of apportioning the returns to an enterprise among the various assets at its disposal.

2.133 That said, it is sometimes extremely difficult to place a valuation on each type of asset separately. The price of a house usually includes both the value of the man-made habitation as well as the land on which it stands. Similarly, the value of a forest covers the value of the standing timber, the potential of the trees to regenerate in the future and the land on which the trees stand. In addition, there may be a significant value to be placed on forest products other than timber and on the recreational use provided. This combination of assets is of no great importance for the SNA since, as noted above, accumulation accounts are compiled for all the assets of a single owner rather than for each asset of the same type across all owners. Finding a way to attribute value to different assets, or even different aspects of the same asset, is thus more of a concern for the SEEA than for the SNA.

5. Decline in the value of an asset

2.134 The value of an asset often declines in use. For produced assets, this decline is measured in the SNA as the consumption of fixed capital. Colloquially, it is referred to as depreciation or amortization, and is the difference between gross capital formation and net capital formation. The classic definition of income is the amount that can be spent in a period while remaining as well off at the end of the period as at the beginning. The consumption of fixed capital is an allowance to ensure that the run-down of fixed capital is taken into account when calculating income according to this definition. If consumption of fixed capital is higher than the acquisition of new fixed capital, then this situation is not sustainable, just as extracting biological resources faster than natural growth is unsustainable.

2.135 The balancing items in the sequence of accounts, described in section D, are always prefixed by the word "gross" or "net". The difference is always the consumption of fixed capital. This is also the difference between gross domestic product (GDP) and net domestic product (NDP). In principle, whenever an income concept is called for, it should be the net version of the aggregates in question that is cited. In practice, it has long been common to use gross measures because some countries did not make estimates of consumption of fixed capital. However, in the environmental context, it would make no sense to worry about the decline in value of environmental assets and not the decline in value of produced assets, hence the use of net measures becomes even more important.

6. Valuing natural resources

2.136 The principles for valuing produced assets and calculating the decline in their value can be applied to natural resources in like manner. Natural resources provide a stream of services to the economy as they are used. The value of these services represents the resource rent of the asset. The decline in value of the resource (ignoring price effects and disasters) can be called the consumption of natural capital, parallel to the consumption of fixed capital.

2.137 The SNA supports this valuation and the calculation of the decline in the value of the natural resource but leaves the value of the decline in the other changes in assets account under the category of "economic disappearance".

2.138 Just as there are reductions in natural resources through extraction, so there may also be additions to stocks. For biological resources, this occurs through natural growth. For subsoil reserves of mineral and energy resources, increases in the known stock levels are the result of mineral exploration and reappraisal. The techniques used to value the stock of a resource and its decline can also be used to put a value on the increase in the level of a resource stock. These increases in value are also recorded in the SNA in the other changes in assets account under the category of "economic appearance".

2.139 The various options of the SEEA treatment of extractions and additions are discussed in detail in chapter X.

7. Incorporating asset accounts in the matrix presentation

2.140 It is possible to modify Table 2.10 to include an asset account for produced assets though some sleight of hand is needed, with the arithmetic built into the matrix presentation. Capital formation needs to appear twice in the accounts – once in the capital account to explain how saving is used and once in the asset account. The entry in the capital account needs to be by sector and that in the asset account by type of asset but the matrix format lends itself to this sort of classification transformation. In addition, consumption of fixed capital needs to appear explicitly to reduce the balancing items to a net basis and to reduce the value of stock in the balance sheet. Table 2.13 shows how this can be achieved.

2.141 The first step is to subdivide the row and column for the capital account into two rows and two columns, one that continues to refer to the capital account (now called 6b) and one referring to the asset account (6a). Column 6a contains new entries above and below the previous extent of the table to show the opening and closing balance sheets of the stock of produced assets and land. The entry for gross capital formation in row 1 is moved to column 6a, showing any addition to the stock level.

Table 2.13. A national accounts matrix with asset account included

		Goods and services (products)	Use of products	Generation of primary income	Use of assets	Distribution of primary income account	Secondary distribution of income account	Use of income account	Capital account	Financial account	Rest of the world economy	Produced assets and land
		1	2a	2b	2c	3	4	5	6b	7	8	6a
												Opening stock levels
Goods and services (products)	1		Intermediate consumption					Final consumption			Exports	Capital formation by asset
Use of products	2a	Output										
Generation of primary income	2b		Gross value added									
Use of assets	2c			Consumption of fixed capital								Consumption of fixed capital
Distribution of primary income account	3			Net value added		Property income						
Secondary distribution of income account	4					Net balance of primary income	Current transfers					
Use of income account	5						Net disposable income					
Produced assets and land	6a								Net capital formation by sector			
Capital account	6b							Net saving	Capital transfers			
Financial account	7								Net lending or borrowing	Acquisition and disposal of financial assets		
Rest of the world economy	8	Imports								Net lending to or borrowing from the ROW		
												Closing stock levels

2.142 The previous row and column for the production account is split to show the use of products, generation of income and use of assets entries separately. Consumption of fixed capital is entered at the intersection of the use of asset row (2c) and the generation of income asset column (2b). Instead of having a matching entry; for the consumption of fixed capital in column 2c, there is an offsetting entry in row 2c under column 6a (the asset account column). Column 2c remains empty; however, since row 2c now has a total value of zero, the rules for balancing the matrix are satisfied.

2.143 In order to balance rows and columns 6a and 6b, we need to enter a value for net capital formation in row 6a and column 6b. The three manipulations have had the following three desired effects: all balancing items appear net; an asset account is produced where the opening stock is modified by the addition of gross capital formation and the deduction of the consumption of fixed capital; and the capital account is reformulated with the result that net saving and net capital formation replace their gross equivalents.

2.144 It is possible to both simplify and expand Table 2.13. The 1993 SEEA also made extensive use of a table where an asset account was superimposed on a set of flow accounts. There, however, the flow accounts were restricted to the supply and use tables. This simpler version can be attained by consolidating rows and columns 3 to 5 and 6b and 7. Countries that have not implemented the full sequence of the SNA accounts are restricted to this version but then the possibility does not exist for them to see flows such as those relating to resource rent and environmental taxes in their full context.

2.145 Although this is not shown explicitly in Table 2.13 it is possible to include an entry for the other changes in assets in column 6a outside the box containing the sequence of accounts and immediately above the closing stock level. Further, just as the supply and use table, the input-output table and the national accounts flows matrix can all be presented as hybrid tables by the addition of environmental flows, so Table 2.13 can be presented in a hybrid form. In addition to the environmental flows, stocks of environmental assets can be shown alongside the stocks of opening and closing stock levels above and below the flows part of the table. Table 20.7 in chapter XX of the 1993 SNA shows how a complete integrated set of flow accounts and balance sheets are reconciled in one national accounting matrix.

G. Integrating environmental adjustments in the flow accounts

2.146 The fourth and last main category of accounts in the SEEA comprises accounts that attempt to measure, exclusively in monetary terms, depletion and degradation of the environment and how this would modify the conventional measures of economic activity. However, although the idea is simple, implementing it is not. There are theoretical, practical and institutional reasons why a statistical office may not implement this part of the SEEA or at least not yet. These issues are important and are discussed at some length in chapter X. Here the discussion focuses solely on the theoretical components of this sort of extension to the SNA.

2.147 Valuing inputs into the economic system is the first and easier step. Since these inputs are incorporated into products that are sold in the marketplace, in principle it is possible to use direct means to assign a value to them based on market principles. Even within the SNA, such valuations are sometimes made, though the results are placed in the other changes in assets account rather than in the flow accounts. Thus, another way of looking at the process of incorporating the use of environmental inputs into the system is to relocate some of the other changes in assets items into the accounts portraying transactions.

2.148 Use of environmental assets as inputs into a production process becomes a matter of concern only if use now threatens the availability of the resource in future. Such issues concern the measuring of depletion of resource stocks. They are treated in the subsection 1 below.

2.149 Because residuals are an output rather than an input, there is no direct way to assign a value to them. All the indirect ways of valuation depend to some extent on “what if” scenarios. What if production processes changed so as to limit residual emission? What if the damage caused by residuals was valued? Such questions quickly lead from a purely statistical approach into the realm of modelling.

2.150 Some actions have already been taken to limit residuals generation or to mitigate the impact of those that are emitted. The expenditures for this purpose are sometimes referred to as defensive expenditures. Considering how to ensure that increased defensive expenditure does not simply show up as increased economic growth is the subject of subsection 2. Various possible approaches to valuing residuals that are not blocked or negated by defensive expenditure are the subject of subsection 3.

1. Showing depletion in the accounts

Valuing natural resources

2.151 The question of valuing natural resources was discussed above. Natural resources, like produced assets, provide capital services to the production process and these are remunerated in the gross operating surplus generated. The gross operating surplus is that part of value added that remains after deducting the compensation of employees and the other taxes less subsidies on production. This operating surplus can be partitioned to show how much is due to produced assets and how much to natural assets. The part due to natural assets is the resource rent. The other part we will call economic rent though, to be accurate, it should really be called other economic rent. The value of the stock of the assets, whether produced or non-produced, can be equated with the present discounted value of the rent they will yield over their effective life. This is the basis of the valuation of assets used for balance sheet purposes when direct market prices are not available.

2.152 Economic rent can be partitioned into a part that represents the decline in the value of the asset, sometimes referred to non-technically as the cost of "using up" the asset, and a remainder that represents the return to the owner of the asset. If there was no return to the asset, there would be no incentive to acquire it in the first place. Conceptually, resource rent can also be partitioned into a part representing the decline in the value of the resource and a part representing the return to using the resource in production. If a renewable resource is not subject to depletion, there is no decline in the value of the resource and the whole value of the extracted resource represents a return to its use in production.

2.153 In the SNA, the decline in the value of the produced assets is described as the consumption of fixed capital and it is deducted from the gross operating surplus to derive the net operating surplus. The net operating surplus thus covers the return to the produced asset plus the whole of the resource rent. The argument in favour of adjusting the national accounts aggregates for the use of natural resources is that a further deduction should be made from the net operating surplus to allow for the decline in the value of the natural resource. Such an adjustment would give a figure for the depletion-adjusted operating surplus. This would be continued through the sequence of accounts and result in other depletion-adjusted aggregates, notably domestic product and national income, and also saving.

2.154 Two questions arise. The first is related to the proposition that it is possible to partition resource rent into one part representing the decline in the value of the asset and another part representing the return to the use of the asset in production which is regarded as income.

2.155 The SNA prior to the 1993 version assumed that natural resources were so abundant that there was no decline in their value (or even that they were so abundant that they had no value) and that the whole of the resource rent could rightly be treated as income.

2.156 The opposite view is taken by some commentators. The whole of the resource rent should be considered a decline in value of the stock of the resource and none of it regarded as income. This is equivalent to saying that the present value of the stock is calculated as the sum of future services without discounting and that the use of natural resources is treated as intermediate consumption.

2.157 The majority (but not unanimous) opinion is that a position in-between these two is to be preferred. Whether the stock is declining should be a matter for investigation and if it is, there is a case for making an adjustment to the operating surplus and other balancing items in the accounts.

2.158 The second question concerns how to treat additions to natural resources. In the case of biological resources, most commentators think it reasonable to affirm that if the harvest in any year is no greater than natural growth in that year, then the stock of the asset has not declined and the whole of the harvest can be regarded as income. (This position assumes that the composition of the resource is stable; clearly, a different conclusion could be reached if some species or some age cohorts became scarce.) This conclusion is consistent with the first and third positions discussed above on partitioning the resource, but not with the second. Here, the argument is that the measures of income in the SNA all relate to income from production and since natural growth of non-produced assets is by definition not a production process, the increase in value of the resource stock due to natural growth cannot be regarded as income and so cannot be offset against a charge on income for the use of resources.

2.159 If depletion is to be calculated net of natural growth in the case of biological resources, how should discoveries of subsoil assets be treated? Here opinion is much more divided, a main cause of which is the recognition that, unlike biological resources, mineral deposits are not renewable on a human timescale. One solution is to say that, in this case, the whole of the extractions should be deducted from net operating surplus with no offsetting element due to new discoveries.

2.160 Another response is that, clearly, mineral discoveries are the result of production and that the resulting asset should be a "developed natural asset" which incorporates the value of both the mineral exploration and the mineral deposit. This asset is characterized as a produced asset and any decline in value of the stock is a deduction from income, but it will show in the calculation of the consumption of fixed capital and thus in net domestic product, without any further deduction being necessary. (The consumption of fixed capital relating to the developed natural asset does not necessarily have to be merged indistinguishably with that for other fixed capital but can be shown separately, as illustrated in the Economic and Environmental Satellite Accounts released by the United States Bureau of Economic Analysis in 1994.)

2.161 The middle way is to argue that, while mineral deposits themselves are not renewable, known and proved deposits are renewable, since mining companies typically establish not the totality of reserves but just enough to warrant opening the mine. As the known stocks are depleted, they search for more. This is how some countries have had a "stock" of oil sufficient for 10 years for over 20 years. This argument suggests offsetting discoveries against extraction.

Incorporating depletion or extraction in the accounts

2.162 Conceptually, the changes that need to be made to the accounting matrix so as to incorporate a depletion adjustment are very similar to the changes made to accommodate the asset account and the allowance for consumption of fixed capital described in the previous section. The resulting matrix is shown in Table 2.14. Row and column 9a are moved within the monetary boundary and another row and column, 2d, are introduced to show that the use of these assets. All the balancing items are now prefixed by "dp" to show that they are now depletion-adjusted rather than simply net. (This example assumes that the third option as given in paragraph 2.161 is adopted. If, instead, only extraction of mineral deposits is to be shown in the flow accounts, there will still be an entry below the flow accounts matrix for discoveries.)

2.163 Based on the numerical example of the SEEAland data set, and assuming these data are realistic for an economy well endowed with natural resources, some illustrative numbers are given in Table 2.15 below. A more detailed version of the same information is given in Table 10.4 in chapter X.

Table 2.14. Incorporating depletion in the hybrid matrix

			National economy							
			Goods and services (products)	Use of products	Generation of primary income	Use of produced assets	Use of natural resources	Distribution of primary income account	Secondary distribution of income account	Use of Income account
			1	2a	2b	2c	2d	3	4	5
National economy	Goods and services (products)	1		Intermediate consumption						Final consumption
National economy	Use of products	2a	Output							
National economy	Generation of primary income	2b		Gross value added						
National economy	Use of produced assets	2c			Consumption of fixed capital					
National economy	Use of natural resources	2d			Depletion of natural resources					
National economy	Distribution of primary income account	3			Depletion adjusted (dp) value added			Property income		
National economy	Secondary distribution of income account	4						Dp balance of primary income	Current transfers	
National economy	Use of income account	5							Dp disposable income	
National economy	Produced assets and land	6a								
National economy	Capital account	6b								Dp saving
National economy	Financial account	7								
National economy	Natural resources	9a								
	Rest of the world economy	8	Imports					Primary income flows to the ROW	Current transfers to the ROW	
	Natural resources	9a								
	Ecosystems	9b		Ecosystem inputs to production						Ecosystem inputs to consumption
	Residuals	10		Residuals reabsorbed by production						
	Rest of the world environment	11		Environmental inputs to production						Environmental inputs to consumption
	Other changes in assets	12								

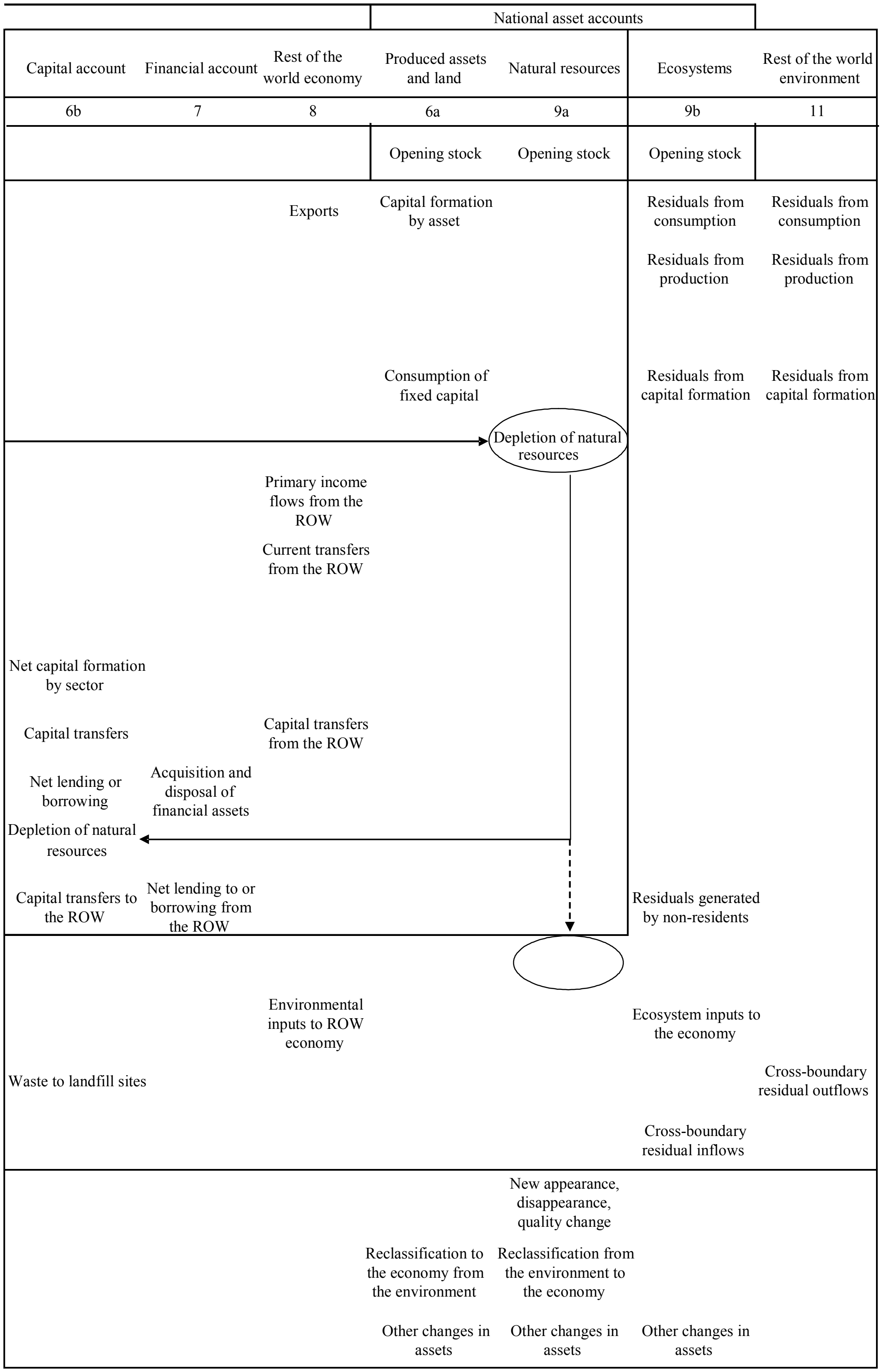

National asset accounts
Capital account
Financial account
Rest of the world economy
Produced assets and land
Natural resources
Ecosystems
Rest of the world environment
6b
7
8
6a
9a
9b
11
Opening stock
Opening stock
Opening stock
Exports
Capital formation by asset
Residuals from consumption
Residuals from consumption
Residuals from production
Residuals from production
Consumption of fixed capital
Residuals from capital formation
Residuals from capital formation
Depletion of natural resources
Primary income flows from the ROW
Current transfers from the ROW
Net capital formation by sector
Capital transfers
Capital transfers from the ROW
Net lending or borrowing
Acquisition and disposal of financial assets
Depletion of natural resources
Capital transfers to the ROW
Net lending to or borrowing from the ROW
Residuals generated by non-residents
Environmental inputs to ROW economy
Ecosystem inputs to the economy
Waste to landfill sites
Cross-boundary residual outflows
Cross-boundary residual inflows
New appearance, disappearance, quality change
Reclassification to the economy from the environment
Reclassification from the environment to the economy
Other changes in assets
Other changes in assets
Other changes in assets

Table 2.15. Illustrative figures for domestic product adjusted for extraction and depletion

		Billions of currency units	Index (GDP=100)
1	Gross domestic product	692.4	100
2	Consumption of fixed capital	104.4	
3=1-2	Net domestic product	588.0	84.9
4	Decline in the value of resource stocks due to extraction	58.6	
5=3-4	Extraction-adjusted domestic product	529.4	76.5
6	Decline in the value of resource stocks due to extractions net of discoveries/natural growth	12.8	
7=3-6	Depletion-adjusted domestic product	575.2	83.1

Source: SEEAland data set.

Ownership

2.164 There is an interest in knowing not only the total level of extractions being made from the environment, but also to whom the benefits of extractions are accruing. The question of the allocation of resource rent between the extractor and the owner is discussed in chapter X. In many countries, government retains ownership as guardian for the public, and what are described as taxes may sometimes represent the economic return to government as owner of the asset. It is the desire to be able to follow through the beneficiaries of resource rent that leads to dealing with environmental accounting within the full SNA system and not just within the context of a supply and use table.

Ecosystem inputs

2.165 Ecosystem inputs cover the use of water, oxygen to permit respiration and combustion, and other natural inputs required to sustain plant and animal growth. If it were possible to place a value on the stock of these inputs, it would in principle be possible to treat them exactly in parallel with natural resources. However, this is neither practical nor especially interesting. On the whole, it is the quality of air, rather than the physical quantity, that is of concern. This is sometimes true also for water though situations are increasing where there is a real scarcity of water. If such situations persist, it is probable that water will ultimately acquire a market value and, in that case, could be incorporated in the accounts following the principles outlined above.

2. Accounting for defensive expenditure

2.166 The scope of defensive expenditure is not well defined and is potentially extensive. In order to be specific, the discussion in the Handbook centres on the subject of environmental protection expenditure, while recognizing that there may be other types of expenditure with as good a claim to being “defensive” as this one.

2.167 A number of commentators suggest that defensive expenditure should simply be left out of national accounts calculations. Others suggest that it be reclassified from final consumption to intermediate consumption. Chapter X looks at these propositions and explains why they are not plausible in accounting terms. Basically, it is not possible to delete an element from the accounting matrix, or reallocate it, without working through the consequences so as to ensure that the final system still balances for each row and column pair.

2.168 A symmetric treatment of environmental protection expenditure by government and industry cannot be achieved simply by omitting some part of the accounting system. However, we can achieve a form of symmetry by reclassifying some of the existing transactions.

2.169 Roads represent fixed capital formation. They are subject to extensive repairs and maintenance to keep them in good condition. The 1968 SNA (United Nations, 1968) took the position that repairs and maintenance would be sufficient to ensure that a road lasted forever and thus there was no consumption of fixed capital allowance for roads in that version of the system. Gross capital formation was taken to be also a measure of net capital formation and all repairs and maintenance were treated as intermediate consumption.[7] There is another possible way to reach a similar position though, one that had been in use in a number of Scandinavian countries before they adopted the 1968 SNA. This is sometimes known as the "gross gross" method of recording capital formation (Aukrust, 1994).

2.170 The gross approach to recording of environmental protection expenditure is one way to achieve a symmetric treatment of such expenditure by government and industry. If the expenditure undertaken by an industry is treated as both capital formation and consumption of fixed capital, the level of output of the industry of its other products will not alter. Gross domestic product (GDP) will increase by the amount of the environmental protection expenditure but net domestic product will not change. The change in classification of government current environmental protection expenditure to capital formation will not affect GDP, though some final consumption will now appear instead as fixed capital formation. On the other hand, net domestic product will fall by the amount of this expenditure just reclassified. In this way, we have a symmetric recording of environmental protection expenditure between industry and government and the gap between GDP and net domestic product (NDP) is increased by the whole amount of this expenditure, by increasing GDP by the current expenditure by industry and reducing NDP by the current expenditure by government.

2.171 Total expenditure on environmental protection expenditure in the SEEAland data set is of the order of 2 per cent of GDP. About half is in the form of intermediate consumption and one third in the form of final expenditure. If the suggestions above are implemented, then GDP increases by about 1 per cent and NDP decreases also by about 1 per cent. The combined effect is to increase the gap between GDP and NDP by about 2 per cent, a figure roughly commensurate with the change caused by including a depletion adjustment to the accounts. Details of these calculations are given in Table 10.5.

3. Accounting for degradation

2.172 There are two problems raised by the question how to incorporate the effects of degradation in the national accounts. The first is how to place a value on degradation; the second, how to locate this valuation in the accounts.

2.173 One answer to both problems is to change not the accounting system but the economic system that the accounts are trying to measure. The goal is not really to measure degradation "perfectly" but to devise policies that reduce the causes of degradation. This leads to asking how much it would cost to avoid the generation of residuals by changing production and consumption patterns. Any non-trivial change in these patterns will have consequences throughout the whole economy so a comprehensive answer must call on the techniques of modelling to calculate the effects.

2.174 The other approach is to look at the damage caused by residual generation. Insofar as pollution reduces the productivity of assets, this should be taken care of in the measurement of consumption of fixed capital and the depletion of natural resources. For example, if the excessive use of pesticides or

[7] This position was changed in the 1993 SNA which recognized that, even with regular maintenance, roads eventually need complete renewal. This is not the point at issue at present, though.

fertilizers eventually reduces the fertility of the soil, the agricultural yield will fall, affecting GDP directly, and the value of the land will also fall, reflecting the decrease in the expected future yields. The impact on human health cannot be captured in this way, however. Chapter IX looks at the possibility of deriving an estimate for the damage to health caused by residuals. Such an approach represents a divergence from the standard SNA approach which makes no attempt to measure welfare derived from consumption – it simply records the costs as a (hopefully) objective measure of minimum satisfaction gained. However, this too, like the modelling approaches mentioned above, is an important development for statisticians in government to be aware of.

2.175 It is very instructive to make estimates of the costs of avoiding residual generation and the benefits to be gained (that is, the avoidance of damage) and most of chapter IX is concerned with the possible techniques that may be used and their comparative strengths and weaknesses. Many of the uses will be deployed in the context of particular projects or situations and, indeed, this may be the context in which valuation of degradation is used. It is possible, though, to contemplate how a global adjustment for the valuation of residuals would affect the accounting framework developed above and the implications for macro-aggregates.

Cost-based estimates of valuing degradation

2.176 There are two main types of cost-based estimates. The first of these is the maintenance costing technique advocated in the 1993 SEEA. It is a fairly straightforward application of the accounting techniques used in chapter V. It attempts to answer the following question:

> *What would the value of net domestic product have been for the same level of activity if all the costs of environmental degradation had been incurred and internalized within market prices?*

2.177 The problem with this approach is that if the question is posed in respect of significant changes in environmental standards, the resultant price rises involved are likely to bring about a change in behaviour that would affect the level of demand for those products. This, in turn, would show up as a change either in the level of output of those products that were affected by price rises or in the technology of production to reduce dependence on the newly expensive products. Nevertheless, for marginal changes in standards, this technique may be used to place an upper bound on the impact on NDP of shifting to more rigorous environmental standards. The aggregates from such an exercise are referred to as "environmentally adjusted". In principle, this adjustment can be applied to either gross or net measures of domestic product or national income so that a family of measures is available. They are referred to here as eaNDP, eaNNI etc. (In the 1993 SEEA, eaNDP was referred to simply as EDP. More exact abbreviations are used here to make clear whether gross or net concepts are implied.)

2.178 The second type of cost-based estimates, known as "greened economy modelling", attempts to resolve the problems raised by maintenance cost approaches for the non-marginal cases of changes in environment standards. It attempts to answer the following question:

> *What level of gross domestic product could be achieved if producers and consumers faced a different set of relative prices in the economy owing to the existence of actual prices for environmental functions?*

2.179 The philosophy underlying this approach is that the only way to achieve given environmental standards is to change the patterns of economic behaviour. It is thus a modelling approach whereby the least-cost solution to achieving these standards over a given time path is determined within a CGE (computable general equilibrium) model where the levels of output, demand, prices and incomes can all be altered and all implied costs are fully internalized. Again, there is a similar family of aggregates resulting which are designated by the prefix "ge" as in, for example, geGDP. These measures are to be seen as forward-looking estimates and not ex post accounting measures.

2.180 A particular application of the greened economy model aims to determine not just a set of values for output, demand and so on that satisfy the national accounting balances but levels of output leading to levels of income that are sustainable over a given time period. It attempts to answer the following question:

What level of income and environmental functions can be sustained indefinitely?

2.181 Built into the model is a very firm commitment to maintaining environmental standards to the point of restricting economic activity, as necessary, to achieve this. It is thus the only measure that addresses the question of long-term sustainability directly but it is the most complex in terms of the model specification. The main aggregate from this approach is referred to as SNI (sustainable national income).

Damage-based methods of valuing degradation

2.182 Damage-based measures derive from the impact of actual residual generation. The starting point is the table of residuals generated as in chapter III. The impact on different "receptors" is then estimated. When the damage is inflicted on economic assets, the impact should be captured in measures of consumption of fixed capital and environmental depletion, but this may not always be the case in practice. One of the biggest impacts, though, could be on human health. In line with an extended Hicksian definition of income, "damage-adjusted income" is derived from net domestic income by deducting all damages arising from the impact of residual generation including those to health. This approach attempts to answer the question:

What is the impact on the level of NDP of environmental impacts on natural and man-made capital and on human health?

2.183 Damage-adjusted income is thus a first step towards converting GDP-type measures to welfare indices. Many other aspects of welfare are deliberately ignored. In terms of current-account transactions, no attention is paid to consumer surplus, utility considerations, or the value of household services, for example. In terms of an extended measure of wealth, both natural capital and that aspect of human capital relating to health are covered, at least in terms of changes. However, there is no extension to social capital or a more comprehensive form of human capital including education. More importantly, there is no inclusion of the services that result from an undamaged environment or the remaining services that an already polluted environment still provides. The damage adjustments to macro-aggregates suggested here are thus better seen as measures of the difference to macro-aggregates that would be caused by inclusion of this one aspect of welfare, rather than as an alternative estimate of the level of those aggregates.

Accounting aggregates

2.184 If the maintenance cost approach to valuing degradation suggested in the 1993 SEEA is followed, new estimates for intermediate consumption and capital formation will result without this extra expenditure being resolved in accounting terms. It can be used as an upper bound on the adjustments that would be necessary to the accounts for marginal changes to environmental standards. A full resolution, though, requires a modelling approach to determine where the extra supply for the newly demanded products comes from and what the consequences are throughout the rest of the economy.

2.185 This comes close to the greened economy solution. Here, no new accounting techniques are required. It is the economy itself that is being changed, not the accounting system.

2.186 The damage-based approach is radically different from all other techniques suggested in the Handbook, since it moves away from pure market valuation as the means of quantifying economic flows. As indicated above, it is better seen as a means of making a statement of comparison between two observations rather than as a means of supplying an estimate for direct comparison with GDP or NDP as measured in the SNA.

4. Depletion and degradation

2.187 Many people concerned about the impact of the economy on the environment are more worried about the consequences brought about by excessive generation of residuals than with the use of natural resources. Whereas 10 years ago it may have been true to say that the industrialized countries cared about pollution and developing countries about resource use, there is no longer such a clear divide (if there ever was). Today, all countries are concerned about the levels of residual generation especially in major urban areas and concern is also rising about the use of water as both an input and a sink for activities.

H. Background information

1. The SEEAland data set

2.188 All the numerical tables in this chapter use data from the SEEAland data set. SEEAland is a fictitious country that is resource-rich, having oil and gas deposits, a large fish stock and extensive natural forests. It is industrialized and so produces a relatively significant quantity of various residuals. It boasts international transport carriers, which absorb ecosystem inputs from other countries and discharge residuals into their environment, and also a two-way tourist industry. Although SEEAland has some of the characteristics of a number of European countries that have implemented many of the parts of the SEEA described in the Handbook, it has no known geographical location. The land area, the size of its population and the exchange rate of its currency are similarly unknown.

2.189 The economic accounts for SEEAland are consistent as far as they exist but not complete. Information on the goods and services matrix exists in physical and monetary terms as detailed in tables in chapters III and IV. Information on environmental protection expenditure is given in chapter V, but there are no accounts for resource management activities.

2.190 Chapter VI contains a full accounting matrix for SEEAland but at no point are all the property income flows (especially those relating to financial assets and liabilities) and transfers spelled out. Only those items relevant to environmental accounting are itemized.

2.191 The accounts are fully detailed in respect of the accounts for resource extraction industries and some related industries such as fish farming and mineral exploration. These appear in tables in chapters VII, VIII and X.

2.192 All tables that are drawn from the SEEAland data set have this indicated as the source of the table. Partly for reasons of space, and partly to draw attention to the subject under discussion, different tables include different features of the data set. Nevertheless, they are all intended to be mutually consistent and coherent. Table 2.16 is intended as a reference table that brings together the main features of the tables appearing in later chapters. In some cases, totals are shown without any corresponding components. These are cases where totals are sufficient to establish the integrity of the data set but the underlying detail is not particularly relevant to environmental issues; hence, no disaggregation is available.

2. Further information on specific accounting issues

2.193 The chapters that follow are intended to contain sufficient background for the different accounting issues so that someone without a detailed knowledge of the SNA can follow the argument. The explanations, though, are never as extensive as those given in the SNA; and interested readers may wish to follow up on particular subjects. References to the SNA are frequent whether by chapter or paragraph number. In addition, and especially for those readers familiar with the SNA, annex IX contains a list of the accounting links between the SEEA and the SNA. Box 1.1 in chapter I links the accounting issues and the chapters of the present publication that examine them.

Table 2.16. Reference table for the SEEAland data set

	Flow accounts	Extraction of oil and gas		Forestry		Capture Fishery		Aquaculture	
		Use	Resource	Use	Resource	Use	Resource	Use	Resource
	Production account								
1.	Output		133 167		2 444		6 642		6 434
2.	Intermediate consumption	19 124		826		2 863		5 438	
	Of which environmental protection services								
	cleaner and connected products								
	Other								
3.	**Gross value added**	**114 043**		**1 618**		**3 779**		**996**	
	Taxes on products								
	Of which environmental taxes								
	GDP at market prices								
	Extended generation of income account								
4.	**Gross value added**		**114 043**		**1 618**		**3 779**		**996**
5.	*less* compensation of employees	6 738		413		1 390		431	
	less other taxes less subsidies on production	3 193		- 19		71		0	
	of which taxes on production	*3 210*		*0*		*95*			
	subsidies on production	*- 17*		*- 19*		*- 24*			
6.	***equals* gross operating surplus**	**104 112**		**1 224**		**2 318**		**565**	
7.	*less* services of produced biological fixed capital								
8.	*less* services of other fixed assets	45 858		668		1 486		368	
9.	*plus* returns to produced biological fixed capital								
10.	*plus* returns to other fixed capital		20 938		290		516		128
11.	***equals* net operating surplus**	**79 192**		**846**		**1 348**		**325**	
12.	*less* harvest of natural biological resources			242		82			
13.	*less* extraction of subsoil assets	58 254							
14.	*plus* returns to natural biological assets								
15.	*plus* returns to subsoil assets		28 870						
16.	*plus* natural growth of biological assets				0		0		
17.	*plus* discoveries of subsoil assets		16 631						
18.	***equals* Depletion-adjusted operating surplus.**	**66 439**		**604**		**1 266**		**325**	
	Distribution of primary income account, Secondary distribution of income account, Use of income account								
19.	**Depletion-adjusted operating surplus**		**66 439**		**604**		**1 266**		**325**
	Imports								
	Exports								
20.	Compensation of employees								
	Taxes on products								
	Of which environmental taxes								
	Taxes less subsidies on production								
21.	Property income	45 500							
	Specific taxes on income from extraction	4 200							
	Taxes on income								
	Of which environmental taxes								
22.	Consumption expenditure								
	of which environmental protection services								
	cleaner and connected products								
23.	**Depletion-adjusted saving**	**16 739**		**604**		**1 266**		**325**	
	Capital account								
24.	**Depletion-adjusted saving**		**16 739**		**604**		**1 266**		**325**
25.	Gross fixed capital formation	30 778		269		1 087		304	
	Of which environmental protection services								
	purchase and sale of property rights								
26.	Consumption of fixed capital	-24 920		- 378		- 970		- 240	
27.	Change in inventories			- 120				311	
28.	Land improvement			0					
29.	Harvest of natural biological resources			- 242		- 82			
30.	Depletion of subsoil resources	-29 384							
31.	Natural growth of biological assets								
32.	Discoveries and reappraisals of subsoil resources	16 631							
33.	**Net borrowing or lending**	**23 634**		**1 075**		**1 231**		**- 50**	

Millions of currency units

Other industries		Owner of subsoil assets (government)		Households		Rest of the world		Nature		Total		
Use	Resource	Use	Resource	Use	Resource	Use	Resource	Use	Resource	Use	Resource	
	1137 713										1286 400	1.
635 749										664 000		2.
										8 900		
										600		
501 964										**622 400**		**3.**
										70 000		
										2 000		
										692 400		
	501 964										**622 400**	**4.**
324 453										333 425		5.
755										4 000		
1 195										*4 500*		
-2 440										*-2 500*		
176 756										**284 975**		**6.**
140										140		7.
193 118										241 499		8.
	140										140	9.
	115 226										137 099	10.
98 864										**180 575**		**11.**
										324		12.
										58 254		13.
												14.
											28 870	15.
									263		263	16.
											16 631	17.
98 864								**263**		**167 761**		**18.**
	98 864								**263**		**167 761**	**19.**
							363 000				363 000	
						403 000				403 000		
					333 425						333 425	20.
			70 000								70 000	
			3 000								*3 000*	
			4 000								4 000	
			45 500								0	21.
			4 200								0	
										68 000	68 000	
										2 000	*2 000*	
		159 000		347 400						506 400		22.
		1 800		*2 970*								
				600								
98 864		**-35 300**		**-13 975**		**-40 000**		**263**		**28 786**		**23.**
	98 864		**-35 300**		**-13 975**		**-40 000**		**263**		**28 786**	**24.**
112 300										144 738		25.
										100		
										3 000	*3 000*	
-77 892										-104 400		26.
1 071										1 262		27.
										0		28.
										- 324		29.
										-29 384		30.
								263		263		31.
										16 631		32.
63 385		**-35 300**		**-13 975**		**-40 000**		**0**		**0**		**33.**

Chapter III. Physical flow accounts

A. Overview

1. Objectives

3.1 The economy as we know it cannot function without drawing in natural resources from the environment and using the environment to absorb the unwanted by-products of economic production. Measuring the flows of particular resources into the economy and emissions from it can therefore provide instructive information. It can show, for example, whether the amount of material passing through the economy is increasing, whether it is increasing faster than the rate of growth of the economy, and whether it is increasing in per capita terms. This can be especially useful in the case of trying to minimize the generation of dangerous wastes, for example.

3.2 Measuring physical flows is a non-trivial task. It requires large amounts of basic data, consistent classifications and units of measure and an agreed framework within which data can be structured at different levels of disaggregation. It also requires an understanding of the purposes for which the resulting tables can be applied. All of these are topics covered by the present chapter.

3.3 Not only is information on physical flows directly useful, but working in physical terms does not in most cases require in-depth knowledge of economic accounting. For this reason, both the production and use of physical flow accounts may be more accessible to those who are orientated more towards the natural sciences than towards economics. While it is usually possible to compile data in physical terms without the corresponding economic values, compiling monetary accounts is facilitated by a foundation of physical accounts.

3.4 There are, of course, limitations to compiling data in purely physical terms. First, the scientific uncertainty surrounding physical estimates of natural resource or residual flows can sometimes be as large as the uncertainty surrounding economic measures. Second, in some cases, physical estimates require the same information required for estimates of economic values. For instance, the quantity of oil classified as reserves depends on the future path of costs, oil prices and technology. Chapter IV discusses the ways in which physical and monetary flow data can be combined to best exploit the advantages of both.

3.5 Concern for the use of the environment began with worry about the potential scarcity and accelerating use of natural resources. Increasingly, it has shifted to the question of waste emissions into the environment and the relation between these emissions and the economic processes that generate them. Emissions may be gaseous, liquid or solid and may be released to any of the environmental media (air, land or water) either directly or after having passed through a treatment process of some sort (a wastewater treatment plant, for example). Throughout this manual, the term "residuals" is used to describe wastes of all types. Formally, residuals are the incidental and undesired outputs from production and consumption processes that generally have no value (though the latter is not an absolute criterion). They may be collected, treated and temporarily stored within the economy but ultimately are released to the environment. A main object of this chapter is to measure the generation of residuals in physical terms and their passage from the economy to the environment. This is done within the context of the other physical flows between the environment and the economy and within the economy.

2. Accounting for physical flows

3.6 The accounting principle underlying the measurement of physical flows is simple. If we measure the total flows of a substance supplied to the economy, this must be equal to the total used by the economy and vice versa. This can be viewed also as stating that the sum of flows from all origins equals the sum of flows to all destinations. The simplest sort of account, a material balance, simply displays this equality for a substance or groups of substances.

3.7 Within the economy, however, substances are transformed. Suppose we consider someone with an axe felling trees in a forest. It is self-evident that the volume of timber existing at a moment in time is not altered by the activity but the standing timber is converted to felled timber which, presumably, will be put to some productive use, plus a small amount of chippings, which might also be used, say, for firewood. Another person, panning for gold in a nearby river, changes earth into a pile of earth plus, hopefully, a small amount of gold which he will put to economically productive use (if only by selling it). In the process, though, he has utilized the river water and may have polluted it with other substances that he removed from their original location in the earth. In terms of a more sophisticated form of these activities, fuel consuming machinery may be used to fell trees and move earth. In this case, the fuel for the machines becomes an input into the activity and the combustion process transforms the fuel into residuals released to the atmosphere as an additional form of output.

3.8 However complex the process, though, if we scrupulously account for all inputs and outputs, we must be able to establish a balance, inasmuch as the first law of thermodynamics states that matter (mass or energy) is neither created nor destroyed by any physical transformation process whether of production or consumption. This principle constitutes the logical basis for a physical bookkeeping system established to consistently and comprehensively record inputs, outputs and material accumulation. The environment also provides services that are essential for the continuation of life and desirable for a more enjoyable one. These are addressed in later chapters, but since they cannot be expressed in physical terms any more than economic services they do not enter into the accounting described in this chapter.

3.9 Following the material balance principle, the physical flow accounts are constructed in such a way as to ensure that net material accumulation is equal to the excess of total inputs over total outputs. This identity may be expressed in terms of inputs and outputs, or in terms of supply and use. It also presupposes a “direction” of flows: what is an outflow to one area is an inflow to another and vice versa. The particular case of interest here concerns the flows between the economic and environmental spheres.

3.10 For an economy and an environment that is entirely self-contained with no flows to and from the rest of the world, the identity could be expressed simply as

> Total inputs to the economy from the environment = total outputs from the economy to the environment + net material accumulation in the economic sphere

Or equivalently as

> Total inputs to the environment from the economy = total outputs from the environment to the economy + net material accumulation in the environmental sphere

In this case, the sign before the net material accumulation in the economy is equal but opposite to that before the net material accumulation in the environment.

3.11 In reality, though, flows with respect to the rest of the world have to be taken into account. Before doing this, it is useful to consider a simple disaggregation of the substances whose flows are to be measured. Resources consist of two types of substances drawn from the environment into the economy. Natural resources correspond to mineral and energy resources, soil, water and biological resources. Ecosystem inputs consist of the gases necessary for combustion and production processes and the inputs needed for biomass growth (carbon dioxide, water and nutrients). Products are generated within the economy and circulate within it. Residuals are those incidental and undesired flows that are generated during production and consumption. They may or may not remain within the economy for some time but eventually they are expelled from the economy into the environment.

3.12 Table 3.1 presents the types of flows that are of interest if we consider the national economy and the national environment and also the economy and the environment for the rest of the world.

3.13 The largest entries, which appear in the upper left, encompass the interactions between the national economy and the national environment. Natural resources and ecosystem inputs flow from the environment to the economy and residuals flow in the opposite direction.

3.14 The upper right encompasses the flows from the national economy and national environment to the economy and environment of the rest of the world and the lower left encompasses the flows from the rest of the world to the national economy and environment. Although these flows will typically be smaller than those in the upper left, they are important when examining the interaction between one country and another.

3.15 The only products shown in this table are those passing between the national economy and the economy of the rest of the world, namely, imports and exports. Flows from the rest of the world environment to the national economy consist of natural resources and ecosystem inputs absorbed by national units operating abroad. These units may also emit residuals to the environment of the rest of the world. Symmetrical entries occur for foreign units operating within the national territory. In addition, there are flows of residuals between the national environment and the rest of the world environment transported by wind and water.

3.16 Except for the cell produced by the intersection of the first row and the first column, the blank cells are not dealt with in this manual. They encompass flows within the national environment or within the rest of the world economies and environment and are thus beyond the immediate boundary of interest.

3.17 The element within the table at top left consists of flows within the national economy. These flows are included in many physical flow tables but for some purposes they may be consolidated out (as in Table 3.1), leaving only the flows into and out of the national economy visible.

3.18 Section B describes in detail the various accounting rules necessary to build up a set of physical flow accounts. Section C describes the basic principles underlying the compilation of supply and use tables in physical terms. Supply tables and use tables are shown separately for each of the ecosystem inputs, natural resources, products and residuals. They are also presented in alternative formats in various combinations (for example, supply table combined for ecosystem inputs, natural resources, products and residuals, supply and use table for products only etc.).

Table 3.1. Typology of flows between the economy and the environment

To From	National economy	National environment	*Rest of the world economy*	*Rest of the world environment*
National economy		Residuals	*Products (exports)*	*Residuals*
National environment	Natural resources Ecosystem inputs Residuals		*Natural resources* *Ecosystem inputs*	*Residuals*
Rest of the world economy	*Products (imports)*	*Residuals*		
Rest of the world environment	*Natural resources* *Ecosystem inputs*	*Residuals*		

3. Elaboration of the accounts

3.19 A number of different accounts are elaborated in section D to demonstrate the flexibility of the system in practice.

3.20 The first two examples deal with alternative ways of treating the recording of physical flows. The first example deals with the recording of recycling and waste handling and the second with the measurement of the growth of cultivated plants and forests.

3.21 Physical supply and use tables can be compiled for one or a group of substances by origin (supply) or by destination (use) of the flows. They may cover a natural resource and its conversion to a product and residuals. If subsequent stages in the use of the product are similarly tracked, then a "product cycle" analysis can be derived. The third example in section D shows such an elaboration for timber and forest industry products.

3.22 The other types of accounts are those used for material flow accounting (MFA) and physical input-output tables (PIOT). Conceptually, there is little to distinguish these two types and each may be considered a special case of supply and use tables for physical flows. However, they differ with respect to detail and focus. They may cover groups of substances or all substances entering, circulating in and leaving the economy. Both show the supply of products, natural resources and ecosystem inputs, and how these are transformed into other products, residuals and a balancing item, namely, the net material accumulation in either the economic or environmental sphere.

3.23 MFA is typically simpler to produce with respect to the direct national flows. It concentrates in particular on flows of resources and residuals and less on flows within the economy. Full economy-wide MFA, however, also requires information on so-called indirect flows and unused extraction. This material is less easy to estimate robustly. PIOT, on the other hand, specifically elaborate the flows of products within the economy in a fair degree of detail so that the uses of resources and causes of residual generation can be identified closely. Examples of both MFA and PIOT are also given in section D.

4. Scope and limitations of the accounts

3.24 While this chapter aims to provide a comprehensive overview of the systems of physical flows in common use, it should be recognized that a complete implementation of the accounts presented here is very ambitious and by no means always necessary for particular studies. The examples given in section D are intended to demonstrate what can be achieved with more modest implementations. These examples use the general principles outlined in the chapter but limit their applicability to specific environmental problems. This is likely to be the most useful way of approaching physical flows, especially for those embarking on the work for the first time.

3.25 While endorsing the use of physical flow accounts and noting the economy-wide application as the conceptual setting for them, it is also appropriate to point out some aspects of environmental accounting that are less well covered by this form of physical accounting.

The limitations of aggregation

3.26 A comprehensive implementation of physical flow accounts may result in the recording of hundreds of different substances. As a consequence, communicating the results of the flow accounts requires some degree of aggregation. The economy-wide physical flow accounts presented in section C require the aggregation of all physical flows using a common unit of measure (usually weight). While the result of this complete aggregation of various materials might serve as a measure of the overall physical size of the economy, it immediately raises questions of interpretation. The implication of an upward or downward movement in such a measure is difficult to determine because the simple aggregation of flows by weight does not account for the other characteristics of the individual materials being aggregated. In particular, it says nothing about their relative impacts on the environment. A downward trend in total material flows might be the result of, for example, less use of construction materials that accounts for a significant share of total material flows in most countries but are relatively benign from an environmental perspective. Such a decline could easily mask an increase in the flows of toxic chemicals, which are used far less in weight terms but have a far greater potential impact upon the environment and human health. Figure 3.1 shows that, often, the unit toxicity of material flows is negatively correlated with the corresponding volume or mass. Developments of this sort would likely be considered undesirable despite the positive trend indicated by the aggregate physical flow measure.

3.27 One means of improving the interpretability of physical flow accounts without abandoning aggregation altogether is to aggregate groups of materials with common characteristics, such as those that contribute to a given environmental issue. For example, all of the gases that contribute to the greenhouse gas effect may be combined into a single aggregate measure expressed in terms of carbon dioxide equivalent emissions. This can be done because scientists have developed a rigorous weighting system (known as the global warming potential) that allows each greenhouse gas to be expressed in terms of its warming potential relative to that of carbon dioxide. An aggregate measure of greenhouse gases has the advantage of compressing a considerable amount of information into a single measure without the risk of masking important changes in the flows of the individual gases that make up the aggregate.

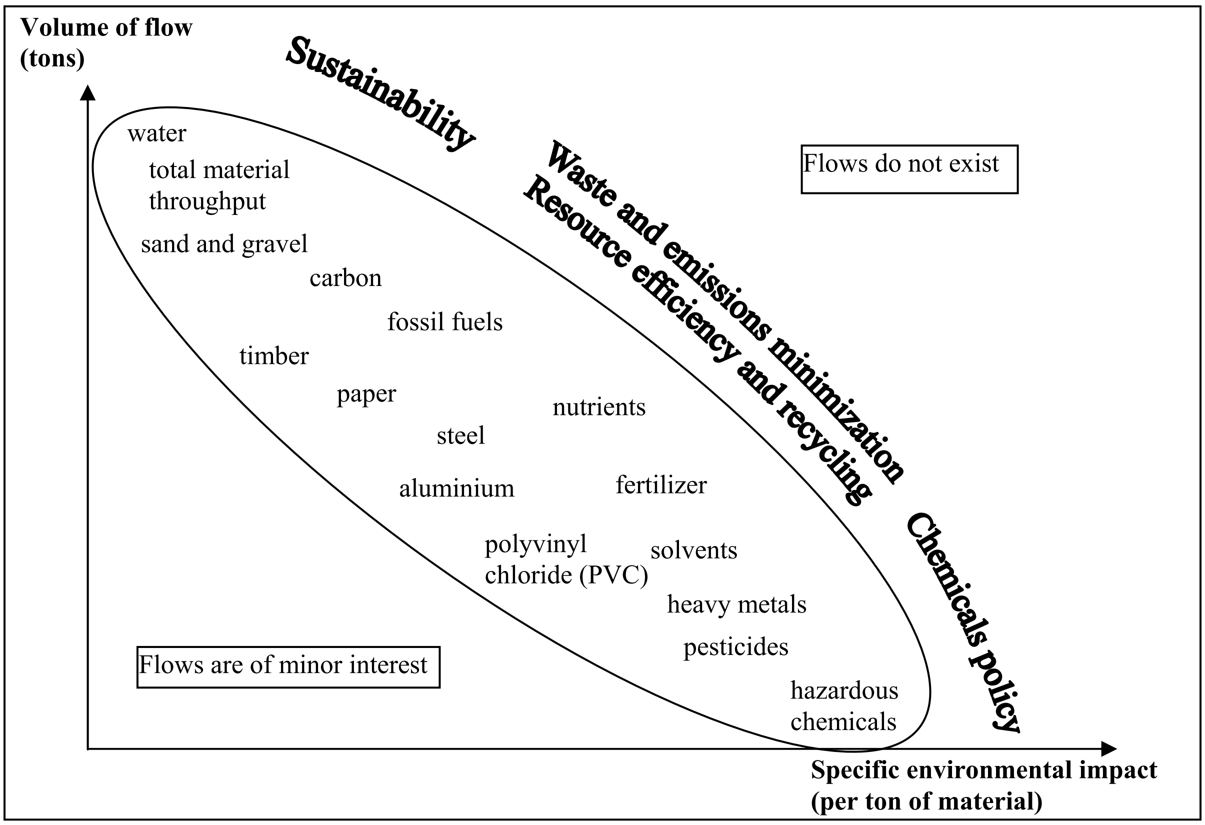
3.28 Several other internationally applied weighting procedures are available that take potential environmental impact into account. They entail:

- The conversion of halogenated hydrocarbons that contribute to the depletion of the ozone layer into chlorofluocarbon (CFC)-11 equivalents according to their ozone depleting potential (ODP).
- The conversion of sulphur and nitrogen oxides and ammonia into acidification equivalents (hydrogen (H^+) ions) on the basis of their relative acidifying potential (AP).
- The conversion of nitrogen–containing residual flows (wastewater discharges and air emissions of nitrogen oxides (NO_x) and ammonia (NH_3) into kilograms of nitrogen in relation to their eutrophication potential (EP) in marine areas.

- The conversion of phosphorous and nitrogen compounds (wastewater discharges and air emissions of NO_x and NH_3) into phosphorous equivalents according to their contributions to eutrophication potential (EP) in inland water bodies.
- The conversion of toxic pollutants on the basis of predicted no observable effect concentrations (NOEC) with respect to ecosystems or acceptable daily human intakes (ADI).[8]

3.29 In addition to aggregating materials according to environmental issue, or theme, it is often useful to convert the flow of a processed material used into an equivalent flow of the same material in its natural state so as to ensure that double counting is eliminated and to identify so-called hidden flows. Further, different energy products can be meaningfully aggregated if they are denominated using a measure of energy content (joules or tons of oil equivalent).

Figure 3.1. Environmental impact and volume of residuals



Source: Steurer (1996).

3.30 While the aggregation of materials according to environmental issue or some other shared characteristic offers a means of avoiding the disadvantages related to use of a single measure, it should be noted that the possibilities for doing so are somewhat limited. There are many more materials for which no weighting scheme is available than materials for which one is available. Increasing the number of toxic materials for which the relative toxicity is known has the greatest potential for adding to this number. This requires sophisticated research, however, and progress will likely be slow. In the meantime, when dealing with materials for which no weighting procedures are available, analysts will

[8] The applicability of this particular weighting procedure is limited, since the NOEC is known for relatively few toxic compounds.

be provided with two options: (a) to aggregate all materials on the basis of weight and encourage users to use caution in the interpretation of the results; and (b) to build accounts on a material-by-material basis and avoid altogether the creation of potentially misleading measures and, where possible, aggregate these materials by common characteristics.

Time and space dimensions

3.31 Problems caused by residuals relate to the flows not only in the current period but also in the past and future periods because of the ability of residuals to cumulate. The effect of the same level of current flow of a residual may be quite different depending on the level already accumulated at the beginning of the period. The question of measurement of stocks as well as flows is addressed in chapter VII but it may be noted here that measurement of stocks is easier for natural resources than it is for residuals because the technical characteristics of a unit of a natural resource do not alter depending on the stock level in the same way as the impact of a unit of a residual does. The damage inflicted by the ambient concentrations of a residual often increases non-linearly with the amount of residual generated. (The price of a natural resource does, of course, alter to reflect increasing scarcity, although, in general, there are as yet few prices relating to the use of the environmental media as sinks.) The accounts described in this chapter detail only the quantity of residuals generated in a single period and do not reveal the consequences of cumulating this amount with past or future amounts of the same (or other) residuals.

3.32 Some environmental concerns relate to particular events, such as the wreck of an oil tanker or a flood. Often, the impact at national level over a whole year may not be very significant but it is highly significant at a given time to a particular locality. While, in principle, accounts such as those described in this chapter could be compiled for smaller areas and shorter periods, it is unlikely that all the data and staff resources required to do this would be available. Some of the impacts of mechanical disruptions, hydrologic changes and structural landscape alterations may be captured in the sorts of accounts on land use or land cover described in the section on land accounting in chapter VIII.

3.33 However, comprehensive translation of residual flows into consequences in terms of changes in quality as well as quantity of assets is considered to be beyond the scope of the SEEA. It is unlikely that a comprehensive description of cause-effect relationships can be laid down in a bookkeeping system, since these are often characterized by non-linear and multidimensional factors. In the SEEA, the steps that can be taken to bridge the gap between cause and effect are the following:

- The accounts can be disaggregated spatially to concentrate on a particular environmental domain or "eco-region" or can be constructed for wider areas, to take into account all relevant cross-border pollution flows.

- The accounts can provide a linkage of residuals to different environmental problems or themes. This is discussed in greater detail later in this chapter and in the next. Sometimes, policy targets are even formulated on the basis of these types of aggregates. Internationally applied examples are the targets related to greenhouse gas emissions, emissions connected to ozone layer depletion and acid rain.

- One particular consequence of residual emissions of major concern is the impact of residuals on health. In order to study the health impacts, it is necessary to make the conversion from residual emission in a given period to the present level of ambient concentration. The technique used is known as estimating "dose-response" functions. Chapter IX discusses in detail the question of estimating damages.

Accuracy considerations

3.34 Lastly, a word should be said about the limits to the accuracy of physical accounts. The estimates of environmental residuals can represent differences between quite large items for supply and use. It is not always the case that physical measures are more accurate than monetary ones. However, while most statisticians are conscious of the accuracy problems surrounding economic accounts, it is easy for them to think that physical accounts are somehow more amenable to exact measurement. In some cases, this is so; but in others, physical measures will be obtainable only by dividing a monetary value by a price, both of which may be subject to measurement error. Nor can all conversion factors be estimated precisely; hence it should be realized that, inevitably, there will be an element of inaccuracy within the accounts.

B. Accounting rules

3.35 In order to compile physical flow accounts, we must establish various sets of accounting rules regarding what units are most suitable; what types of flows are to be measured; and the origin and destination of the flows.

1. Units

3.36 Physical flows are expressed in units of quantity that describe the physical characteristics of the material of the energy or of the residuals in question. A specific physical flow can be expressed in alternative units, depending on the physical characteristic that is taken into consideration. Obviously, the appropriateness of a particular unit depends on the purpose and intended use of the flow account. Standard units of quantity for products as recommended by the World Customs Organization are listed in Box 3.1. These standard units are recommended in the collection and reporting of international merchandise trade on the basis of the Harmonized System. However, for physical flow accounting, weight (kilograms) and volume (cubic metres or litres) are the most frequently used physical characteristics. As far as goods are concerned, the units for weight can be used either net (exclusive of packaging) or gross (inclusive of packaging). While information on gross weight can be useful in relation to analysis of transport needs, separate accounting for the goods and the related packaging is normally to be preferred.

Box 3.1. Standard units of Quantity as recommended by the World Customs Organization

Weight	Kilograms (kg)
	Carat (carat)
Length	Metres (m)
Area	Square metres (m^2)
Volume	Cubic metres (m^3)
	Litres (l)
Energy	Joules
	Tons of oil equivalent (toes)
Electrical energy	1,000 kilowatt-hours (1,000 kWh)
Number (units)	Pieces/items (u)
	Pairs (2u)
	Dozens (12u)
	Thousands of pieces/items (1,000u)
	Packs (u(set/pack))

Source: World Customs Organization (1996).

3.37 Throughout this chapter it is tons that are usually cited, but the option to work in other units when appropriate should be kept in mind. This is especially the case with energy flows where joules or tons of oil equivalent (toe) are most commonly used.

2. Types of flows

3.38 If we consider the flows between and within the economic and environmental spheres, we need to identify flows from the environment to the economy; flows within the economy; and flows from the economy back to the environment. In addition, we may wish to consider some flows whereby material is relocated or transformed by economic activity without leaving the environmental sphere. Flows of four different types of materials are distinguished in the SEEA. ***Natural resources*** cover minerals, energy resources, water, soil and biological resources. ***Ecosystem inputs*** cover the water and other natural inputs (for example, nutrients and carbon dioxide) required by plants and animals for growth, and the oxygen necessary for combustion, excluding water, nutrients or oxygen supplied as products by the economy. ***Products*** are goods and services produced within the economic sphere and used within it, including goods and services flowing between the national economy and the rest of the world. ***Residuals*** are incidental and undesired outputs from the economy that have a value of zero (or a negative value) to the generator. "Residuals" is the single word used in the SEEA to cover all solid, liquid and gaseous wastes. They may be recycled, reused or as is (more usual at present) discharged into the environment. It is important to note that residuals may have a positive value for a unit other than the generator; for example, household waste collected for recycling has no value to the household but may have some value to the recycler. Scrap materials that have a value realizable by the generator (discarded equipment, for example) are treated as products and not as residuals. This topic is discussed further in the first example given in section D.

Natural resources

3.39 As just noted, natural resources cover minerals, energy resources, water, soil and biological resources. From the moment they are sold on markets, they enter the economic sphere and should thereafter be characterized as products in the same way as processed resources or materials.

3.40 The set of natural resources considered in the physical flow accounts closely correspond to those environmental assets described in chapter VII (excluding cultivated biological assets which are regarded as products). The subset of asset types that are relevant in connection with physical flows is presented in annex II. Usually, the classification of physical flow accounts for natural resources will be more specific than the classification in annex II. For example, fossil fuels (classification code EA.111) can be subdivided into coal, lignite, peat, crude petroleum and natural gas; metallic minerals (EA.112) can be subdivided into gold ore, silver ore, iron ore and so on, while aquatic resources (EA.143) might be subdivided according to the various species of fish.

3.41 While the asset classification shown in annex I can be used as a starting point for the classification of the physical flows of natural resources, it is sometimes instructive to use a cross-cutting classification. For example, it may be desirable to show which energy flows relate to non-renewable energy (EA.11) and which to renewable energy in the form of biomass (EA.14). Some types of renewable energy like solar, hydro and wind energy are not included explicitly in the asset accounts but are relevant in relation to the physical flow accounting of natural resources. These types of energy may be included in the accounts under the heading "renewable energy" as an extension of EA.11.

Ecosystem inputs

3.42 There is an important distinction to be made between ecosystem inputs and ecosystem services. Ecosystem services are much wider and include the assimilative capacity of the environment and the provision of biodiversity. Ecosystem inputs are restricted to the substances absorbed from the ecosystem for purposes of production and consumption such as the gases needed for combustion and production processes as well as oxygen, carbon dioxide, water and nutrients. Unlike natural resources, ecosystem inputs are not easily identifiable in any of the products to which they contribute. Care must be taken not to count as ecosystem inputs any chemical substances, water, feeding stuff etc. that are a result of production.

3.43 Although the ecosystem inputs are well defined in principle and should be regarded as distinct from the output arising from the production processes that use them, for pragmatic reasons an accounting procedure might be devised whereby the volume of ecosystem inputs is set equal to the harvest of biomass resulting from the absorption of ecosystem inputs. This is discussed in greater detail in the second example in section D.

Products

3.44 Products are defined in the SEEA so as to be consistent with the SNA. The SNA defines products, also called goods and services, as the results of production (1993 SNA, para. 2.49). Cultivated biological assets are also regarded as products. Obviously, when measuring physical flows, it is goods and not services that are mainly of interest. However, the supply of some services may also involve the delivery of goods, as is the case in the supply of hotel and restaurant services and the provision of government services.

3.45 Products can be classified according to different criteria and objectives and a number of international standards exist (for example the Harmonized Commodity Description and Coding System, the Standard International Trade Classification, and the Central Product Classification (CPC)). The 1993 SNA introduced the Central Product Classification (CPC) for this purpose. It should be noted that the CPC has been developed primarily for economic analysis and that supplementary classifications may be used for the analysis of physical characteristics. For example, the Chemical Abstract System (CAS) together with a toxicity database can be used to identify harmful effects of chemicals. However, in order to ensure international comparability and coherence with the SNA, it seems appropriate to ensure that any supplementary classification introduced in the physical flow accounts can be reaggregated to the CPC. Annex III illustrates various parts of the CPC that are of interest in relation to physical flow accounting.

Residuals

Coverage

3.46 Residuals are the incidental and undesired outputs from production and consumption processes within the economy. The term “residuals” is used throughout the SEEA to designate such flows whether they are to land (including soil), air or water. The distinction between flows to these three “sinks” is made when it is relevant, as is often the case.

3.47 The consumption of goods as intermediate inputs by service industries produces residuals, for example, the tailpipe emissions from a bus that is powered with diesel fuel. The consumption of the service in general generates little in the way of residuals except for, say, a bus ticket thrown away by the passenger. Like services, goods generate residuals in the course of production but also when they are finally consumed and discarded. In physical accounting - but not in monetary accounting - it is the time of discard of the goods that is important, not the time of their acquisition. This results in an inconsistency when comparing monetary and physical accounts. For example, and consumer durables are recorded as "consumed" at the moment of purchase in the monetary accounts and at the moment of disposal in the physical flow accounts.

3.48 It is important to note at which stage the residuals are generated and attributed. For example, food scraps coming from a restaurant will be treated as residuals arising from production; those coming from a carry-out service or from home catering are treated as residuals arising from consumption. On the other hand, consumption of food in a restaurant represents a physical flow from a service industry to households as does the consumption of food from a carry-out service.

Landfill sites

3.49 Residuals are often disposed of in landfill sites and there are different ways in which these flows can be handled. The approach adopted in the SEEA is to treat the operation of managed landfill sites as a productive activity; the landfill sites themselves are treated as a kind of physical capital formation. Because managed landfill sites are generally regarded as entities within the economic sphere, disposing of residuals at such sites is regarded as a flow of residuals within the economic sphere. When materials subsequently leak from a site into the surrounding air, soil or water (including from sites created before rigorous prevention measures were in effect), this should be recorded as a flow of residuals from the economy to the environment. The discussion of borderline issues below includes an alternative treatment of residuals disposed of in landfill sites.

Recycling, reuse and treatment of residuals

3.50 Increasingly, residuals are not discarded directly to the environment, but remain in the economic sphere to be ***recycled*** into new materials, ***reused*** directly or ***treated*** prior to disposal so as to render them less harmful to the environment and human health.

3.51 Recycling is defined as the reintroduction of residual materials into production processes so that they may be incorporated in new products. For example, the reintroduction of old newsprint into a paper mill as an input into the production of new newsprint is considered recycling. Reuse, on the other hand, occurs when a residual material is reintroduced into a production (or consumption) process and used as an input in its original form. The return of glass bottles to the place of manufacture to be refilled with new beverage products is an example of the reuse of residuals. Recycling and reuse can occur spontaneously through market forces if an economic agent (other than the generator) sees an opportunity to generate revenue from sale of the residual. When market forces do not exist or are insufficient to induce the spontaneous recycling or reuse of residuals, government policy may be used to encourage these activities if they are thought to be socially desirable.

3.52 Treatment of residuals occurs when they are sent from the generator to an enterprise that specializes in processing them in order to change them either qualitatively or quantitatively before disposing of them in the environment or in a landfill site. Residual treatment is generally costly to the generator and does not generally result in a saleable material for the enterprise undertaking the treatment. For these reasons, it is usually mandated by government policy.

3.53 Collection and sorting of residuals for recycling and reuse can be carried out both by formal enterprises and, especially in developing countries, by individuals working in the informal sector. Pre-disposal waste treatment is generally carried out only by formal enterprises. Within the national accounts, a formal enterprise that collects and sorts residuals in order to extract items for recycling or reuse is regarded as undertaking production. The value of this production is the value for which the items are sold, plus any supplementary service charges received from the generators of the waste. This must cover any costs involved (the running costs of the trucks needed to collect the residuals, for example). Where individuals in the informal sector collect and sort residuals to find recyclable or reusable products for sale, in principle this also should be recorded as production of an informal nature giving rise to mixed income. Units engaged in treating and disposing waste also undertake production, the value of which is equal to the revenues they generate by charging residual generators for the service they provide or the costs of production.

3.54 In the SEEA, recycling, reuse and treatment of residuals are all regarded as taking place within the economic sphere, that is, the residual flows associated with these activities occur within the economic sphere. The residual flows from the original generator are recorded as supply of residuals and the quantities that remain within the economy for recycling, reuse or treatment are shown to be "used" by industries.

Gross versus net residual flows

3.55 It is useful to distinguish the concept of ***gross residual flows*** from that of ***net residual flows***. Gross residual flows encompass the quantity of residuals generated by all units in the national economy during an accounting period (including leakages from managed landfill sites). Net residual flows encompass the quantity of residuals ultimately expelled into the environment (or into a landfill site) following any recycling/reuse or pre-disposal treatment.

3.56 One way of looking at the question of gross versus net residual flows is from the perspective of aggregate flows of residuals. Figure 3.2 presents a simple economy/environment system that is helpful in demonstrating how the flows in question can be calculated.

3.57 The economy portrayed in Figure 3.2 is very simple. It comprises just two goods-producing industries (1 and 2), and a "residual treatment and recycling" industry, plus households (for the sake of simplicity, the rest of the world is ignored). Figure 3.2 presents the residual flows within this simple economy and between it and the environment. As can be seen, industry 1 produces 100 units of residual A, all of which are sent to the treatment and recycling industry. Industry 2 produces 200 units of residual B, all of which are disposed of directly in the environment. Households produce 150 units of residual C, all of which are sent to the treatment and recycling industry. The treatment and recycling industry itself produces 130 units of recyclable residual C (which is no longer considered a residual but a product), which are purchased by industry 2, and 160 units of residual D and 20 units of residual C, which are disposed of in the environment.

3.58 Looking at this system from the perspective of aggregate residual flows, it is possible to see that the gross residual output of the economy (that is, the sum of all residuals produced by all economic units) is:

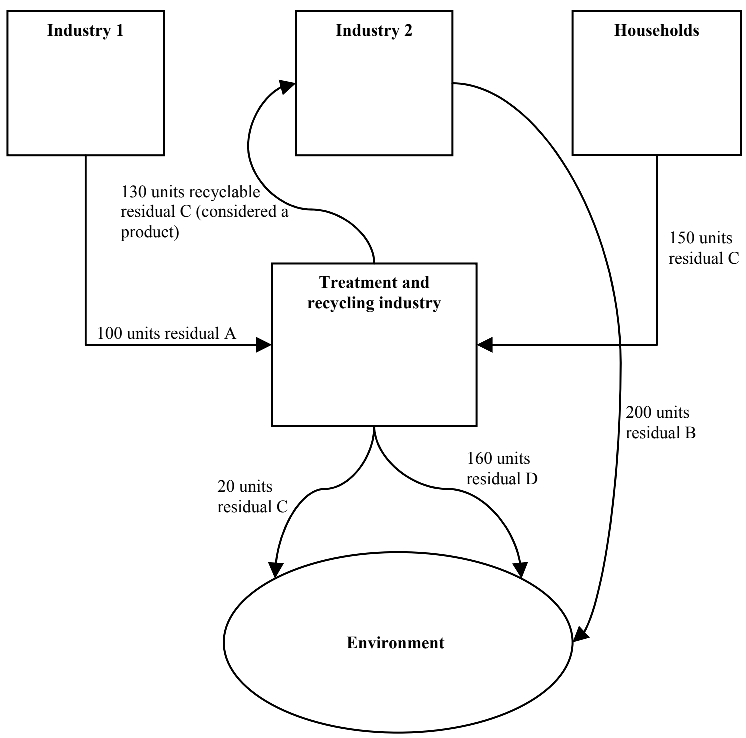
100 units A + 200 units B + (20 +150) units C + 160 units D = 630 units

3.59 It is important to recognize that there is an element of double counting of residuals in this gross flow. This is because all the residuals that are accepted by the treatment and recycling industry and not diverted back into the economy for recycling/reuse must ultimately be disposed of again. These residuals are therefore counted twice in gross residual output; once for the original generator and then again for the treatment and recycling industry. The double counting of residuals in the economy portrayed in Figure 3.2 is equal to 120 units (that is, 100 units A + [150 – 130] units C). In order to eliminate this double counting and determine the amount of residuals ultimately disposed of in the environment, it is necessary to calculate net residual output. This is equal to gross residual output less the amount of residuals "used" by the treatment and recycling industry (630 – [100 + 150] = 380 units).[9] It will be noted that the difference between gross and net residuals (630 – 380 = 250 units) is greater than the double counting of residuals. The difference is made up by the 130 units of recyclable residual C which the treatment and recycling industry sells back to industry 2 as a product. Thus, the total double counting of *materials* in the system (residuals plus products) is equal to 250 units (120 + 130), which is exactly the difference between gross and net residual flows.

3.60 Another way of approaching gross and net residual flows is from the perspective of homogeneous residuals. Here again, gross flows are equal to the sum of the flows of each homogeneous residual from all economic units. Net flows are, as before, equal to gross flows less the amount of the residual "used" by the treatment and recycling industry. In the case of the economy in Figure 3.2, the following homogeneous residual flows can be identified:

	Gross flow (units)	*Net flow (units)*
Residual A	100	100 – 100 = 0
Residual B	200	200 – 0 = 200
Residual C	150 + 20 = 170	170 – 150 = 20
Residual D	160	160 – 0 = 160

Figure 3.2. Residual flows in a simple economy/environment system



[9] Note that in a more complex economy, other industries in addition to the treatment and recycling industry would likely absorb residuals. The calculation of net residual flows would then have to account for all absorption, not just that by the treatment and recycling industry.

3.61 Some commentators argue that the concepts of gross and net residual flows are most meaningful in the context of homogeneous residual materials or thematically related groupings of homogeneous residuals (greenhouse gases, for example). They note that comparing gross and net residual flows from an aggregate perspective can be of limited analytical interest, especially if one's interest is in studying the relative potential environmental impact of residuals before and after recycling/reuse and treatment. This is because the change in residuals affected by the process of treating them before they leave the economy is such that net flows differ from gross flows not only in quantity but also in composition. This can be seen easily in the example provided in Figure 3.2. The figures immediately above show that the relative composition of the aggregate gross and net residual flows is very different. The gross flow comprises 16 per cent residual A, 32 per cent residual B, 27 per cent residual C and 25 per cent residual D. The net flow, in contrast, comprises 0 per cent residual A, 53 per cent residual B, 1 per cent residual C and 42 per cent residual D. Note that in the absence of the kind of information on homogeneous residuals that has been included in Figure 3.2, nothing about difference in composition between gross and net flows can be reported. For this reason, simply recording gross and net residual flows in the aggregate reveals very little about their relative potential environmental impacts, other than the fact that net flows are generally smaller than gross flows.

3.62 Comparing gross and net residual flows of homogenous wastes, on the other hand, is useful in understanding how effective the economy is in diverting specific harmful residuals from the environment. It can also be used to study the trade-offs inherent in residuals treatment. For example, when solid residuals are incinerated, large amounts of various gaseous residuals are created, in addition to smaller amounts of new solid residuals (mainly ash), plus some liquid residuals. Compilation of the gross and net flows of homogeneous residuals associated with incineration would be valuable in an analysis of the environmental desirability of incineration.

3.63 The weakness of compiling gross and net residual flows on the basis of homogeneous residuals is that the number of materials to be tracked may well be very large. Modern economies produce thousands of individual residual materials and accounting for them all would be a mammoth task. It is therefore probable that countries would choose to analyse flows for a selected number of homogeneous residuals (say, those related to a specific environmental issue) rather than for all residuals in the economy.

3.64 In many of the physical flow accounts presented later in this chapter, the concepts of gross and net flows are, for the sake of simplicity, used in the context of aggregate residuals. The reader should bear in mind that these examples are intended to demonstrate the structure and accounting rules of the physical flow accounts; they should not be interpreted as reflecting the only possible approach to such accounts. Indeed, in many instances, physical flow accounts for homogeneous materials are those that countries will wish to construct.

Dissipative residual losses

3.65 The concept of residuals embraces so-called dissipative losses, for example, from car brakes and tyres, from roads through abrasion, and from rain collection systems on roofs (loss of zinc), as well as residuals corresponding to "deliberate disposals" of products such as fertilizers and pesticides. Pesticides, fertilizers and compost, thawing materials applied to roadways in winter, and seeds are all examples of products that are deliberately transmitted to the environment and thus need to be included in the flows from the economy into the environment.

Classification

3.66 Although the determination` that a residual is an output from production or consumption without monetary value to the generator may be theoretically correct, in practice residuals are usually defined and described by means of specific lists of materials. This has a number of practical advantages. The necessary information on whether a potential residual has a price or not may not be available in many cases, whereas the results of waste statistics can be utilized directly when following the list approach. Further, the fact that the strict use of the price criterion means that, depending on the market situation, a material can be defined either as a residual or as a product in different periods or even in the same period, may disturb the interpretation of the flow of residuals. A possible basis for such a list of residuals is the European Waste List (European Communities, 2000) which would have to be extended for this purpose to include other residual flows such as wastewater, water vapour and air emissions.

3.67 Currently, there exists no complete classification for residual flows. One complication is that the flows of residuals overlap each other. For example, landfilled or incinerated residuals result in emissions of gaseous and liquid wastes to the surrounding environment. The problem is to know how to deal with this double counting in a residuals classification. Multi-impact emissions make it difficult to allocate residuals to theme-specific classifications without accepting that there is a degree of double counting. One suggested solution is to have separate classifications for gaseous, liquid and solid residuals. Such a classification is shown in annex IV. It should be noted, though, that this classification could lead to double counting in practice and that for certain purposes it might be better to list various types of residuals without specifying the media that receives the residuals as an integrated part of the classification.

3.68 A desirable characteristic of a residuals classification is that it should provide information on the way particular material flows might influence the environment or human health. In other words, in environmental accounting, attention should also be paid to the qualitative aspects of material and energy flows. Because of changing concerns about specific residuals, for example, hazardous materials, such a classification must be held under constant review if it is to remain relevant to emerging issues.

Borderline problems

Landfill sites

3.69 While the treatment of residual flows to managed landfill sites described earlier is conceptually sound, data availability and legislation in force in a given country may raise a number of issues. For example:

- Not all landfill sites are licensed and controlled. Some may be so poorly managed that there is little point in regarding their use as other than a straightforward disposal of solid waste to the environment. This also applies to dumping in undesignated places.
- Where both controlled and uncontrolled landfill sites exist, it may be difficult to determine the quantity and nature of waste going to each. As more costs are imposed for disposing legally of waste containing dangerous substances, the risk of illegal dumping is likely to increase.
- Even when a site is well managed, the question arises how to treat it when it is full and sealed. Does it remain within the economy as a continuing form of negative land improvement or should it be treated as having been transferred to the environment at the point when it closes down?

- While tracking the leakages from landfill to the environment is desirable in theory, it may be very difficult to obtain such information in practice. Only if the conditions of operating a landfill site stringently prohibit any leakages could such flows be properly regarded as linked to economic activity; more often, they will simply reflect the conditions applied to landfill sites at the time they were opened. Thus, the fate of these sorts of flows, even when waste going to the landfill is recorded as remaining within the economy, are still somewhat ambiguous.

3.70 For all these reasons, in practice some accounts may simply treat all disposals of residuals to landfill as immediate discharges to the environment. This simplified treatment has some consequences for the recording of residual flows. In particular, leakages from landfill sites (for example, methane) will no longer appear as flows from the economy to the environment but as flow within the environment. If the simpler approach is adopted, some simplification of the guidance that follows on compiling various parts of the physical flow accounts will result. This is not mentioned in each instance. The reader would simply note that flows to and from landfills should be replaced by flows to and from the environment.

In situ uses

3.71 A number of environmental assets providing function and services - for example, watercourses for navigation, land for transportation, and land and water as a sink for pollution - are used only in situ and not actually absorbed into the economy through use. In such cases, the natural assets provide services but there is no physical flow out of the environment. There is thus no physical product (good) corresponding to that use of the asset, though it may be that a service charge could be levied on that use. In this case, there will be an asymmetry between physical and monetary accounts with the former showing a zero entry and the latter a non-zero value.

Hidden or indirect flows

3.72 Some activities lead to the displacement of environmental assets but not to their absorption into the economic sphere. These are referred to as indirect or hidden flows. The most obvious example is the overburden from mining operations. In the example described in section C, indirect flows are not shown but alternative presentations are shown in section D.

Water

3.73 Water poses a number of problems since it is possible for it to fall into any of the categories described so far. Water that is naturally absorbed by plants and animals through rainfall or natural watercourses represents an ecosystem input. Water in aquifers that may be extracted for use in the economy is a natural resource. Water that has been abstracted from an aquifer or a water course and is supplied via pipes to households for a fee is clearly a product. Dirty water which is returned to the environment is a residual.

3.74 Water that is abstracted by a farmer for irrigation but that is in excess of the amount absorbed by his plants or animals, or water used for hydropower without being “absorbed” by the economy, could be regarded as a natural resource, a product or simply a type of hidden flow. If extraction rights exist, it seems appropriate to treat the original water body as a natural resource, and the extracted water as a product, whether the extraction rights are paid for or not. On the other hand, the fact that overirrigation and hydro usage simply relocates the water and does not remove it from the environment suggests treatment as a hidden flow. Different choices are possible, depending on the analysis required. For example, water that has been used for irrigation but has not been absorbed by plants may itself have absorbed dissolved substances. Thus, although it is returned to the environment and can be regarded as a hidden flow, there has been a quality change which it may be desirable to capture.

3.75 Water absorbed by plants and animals is normally treated as an ecosystem input when the plants and animals are within the production boundary (cultivated). If the accounts for natural resource (or product) flows include all water extracted for irrigation and drinking water, this will give rise to some double counting. This means that in principle the accounts should allow for such a transformation of natural resources into ecosystem inputs or that the natural resource extraction should be reduced by the amount of ecosystem inputs. However, in practice this will seldom be a problem either because the size of the ecosystem inputs are marginal compared with the often huge amounts of natural resource flows of water or because the natural resource flows on one side and ecosystem inputs on the other are treated in separate accounts for separate purposes. Only in the case of a total accounting for all flows do explicit measures need to be taken to avoid double counting. This topic is discussed further in the second example in section D. The whole question of classifying and measuring water flows is discussed in greater detail in the section on water in chapter VII.

3.76 Water that is piped into a household is a product. Wastewater, which is discharged into the environment is a residual flow. In between, there is wastewater in the sewerage system between the point of generation and the point of treatment in a wastewater treatment plant. Even though the wastewater in the sewerage system remains within the economic sphere, it seems difficult to justify calling it a product; but it is also unsatisfactory to classify it as a residual going first to the environment and then being reabsorbed by the water treatment plant. The solution is to label the emissions at the point of generation as gross residual flows (in keeping with the discussion presented earlier, it is not the overall flow that should be so labelled, but the flows of the constituent materials in the wastewater). The treated emissions (of the individual constituents) from the sewerage plant are then to be labelled as net residual flows. Note that in addition to the net flows of the constituent materials that entered the treatment plant, there will also be new residual flows from the plant (for example, sewerage sludge). These new residuals may be disposed of in the environment (or in a landfill site) or reused in production (as an agricultural fertilizer, for example).

Flows of residuals to the economy

3.77 Household or industrial waste may not be sent to a landfill site but dumped (possibly illegally) in open country or by the roadside. Tankers at sea may wash their tanks (also illegally) or lose their cargo through being wrecked. Efforts might then be made to recover these residuals from the environment and bring them back into the economy either for treatment or for consignment to a landfill site. This is the only case where flows of residuals from the environment to the economy should be recorded. In numerical terms, the amount may be small but, in respect of particular incidents (the wreck of an oil tanker near a protected coast, say) or particular locations, may arouse a sufficient degree of concern to merit identifying these flows explicitly. Note that this particular category of flows is not included in the detailed exposition of the physical flow accounts presented in section C.

3. Determining origin and destination of flows

3.78 In order to set up physical flow accounts, it is necessary first to determine the boundaries whose crossing marks an inflow or an outflow. Physical flows can be set up in relation to individual units, or groups of units, or for the national economy and national environment. Our initial concern will be with the last of these. It is necessary to consider what constitutes the economic sphere and the environmental sphere, and then flows within the economy, and between the economy and other economies, and between the economy and the environment (in both directions), flows between the national economy and another environment and vice versa, and flows within the environment. Once these boundaries are established, the typology of flows in Table 3.1 can be converted into schematic accounts.

The economy/environment boundary

3.79 The economic sphere is defined in relation to the flows covered in the SNA. This means that all flows related to the three types of economic activity covered in national accounts (production, consumption and accumulation) are included. All products originate within an economy, specifically as the outcome of productive activities. Products may incorporate natural resources. Products are destined to be used in the same period in which they are produced in the production of other products (intermediate consumption), or to satisfy final needs (final consumption), or this may be used as capital in the production of other products over a period of time (accumulation). Each of the three activities can generate residuals, inter alia, by burning fuel, by contaminating water or simply by discarding products in total or in part when they are no longer wanted.

3.80 The environmental sphere includes all physical entities other than products. Corresponding to each national economy, there is a national environmental sphere that is associated with the national territory, including the surrounding sea area covered in an exclusive economic zone (EEZ) agreement and the airspace over the country. Open oceans outside an EEZ and airspace outside a national territory are part of the environmental sphere but not part of any country's *national* environment. The environmental sphere provides resources to, and receives residuals from, one or more national economies.

The boundary with the rest of the world

3.81 The boundary of the economic system is established in relation to production by defining "resident" units. While there is a large overlap between resident units and those located within the geographical boundaries of a country, they are not exactly the same. For administrative reasons, an exception is made for embassies, consulates or military bases belonging to foreign countries, which are by convention regarded as resident units of their parent country, and also for the operations of international organizations on the national territory (1993 SNA, para. 4.163). Units intending to operate in a country for less than a year are also regarded as non-resident. These may be specialized construction firms or aid and relief agencies, for example.

3.82 For the purposes of these accounts, it is also important to consider where units operate as well as where they are resident. The majority are resident and operate in the national territory. Some resident units operate abroad. For example, transport equipment used for international travel and for freight operates a good deal of the time outside the national territory. When this is so, the residuals generated at that time are vented into the environment but not into the national environment. The reverse situation also occurs, of course. Some forms of transport also absorb ecosystem inputs in the form of air for combustion. Similarly, fishing vessels operated by non-residents may extract natural resources (legally or illegally) from national waters. Thus, there may be both ecosystem inputs and natural resources flowing from the environment of one country to the economy of another.

3.83 Tourist activity requires careful consideration. If tourists enter to the national economy and use local buses, say, the cause of the pollution generated by the buses may be international tourism but it is generated by a national, resident producer, namely, the bus company. If the tourists use their own cars, filled with petrol bought before they cross the border, then this situation is similar to that of international transport services: the residuals are generated by units resident in one country and discharged into the environment of another.

3.84 It may not always be practical to determine how much foreign tourists contribute to the residuals generated in a country; and if it is thought that the flows in generated by foreign tourists approximately balance the flows out generated by residents travelling abroad, it may be acceptable to ignore this. For countries where tourism is a major net contributor to the economy, though, it will be highly desirable to estimate the contribution made by tourists to national residual generation when they use non-resident facilities (foreign airlines, say) and national facilities (as reflected, for example, by the demand for water in hotels).

3.85 Table 3.2 presents a specific example of the orders of magnitudes that may be involved in measuring the sources and destinations of pollution in a country that is rather densely populated and adjacent to other densely populated areas.

Table 3.2. Origin and destination of pollution in the Netherlands, 1998

Millions of tons

	NO_x	SO_2	NH_3	P	N
Origin of pollution					
Emissions by residents	645	211	170	106	1 059
From the rest of the world					
Non-residents in the Netherlands	39	12			11
Transfer by surface water or air	64	64	19	22	411
Total origin	748	288	189	128	1 481
Destination of substances					
Absorption by producers (recycling etc.)				22	120
To the rest of the world					
Residents in the rest of the world	261	117			82
Transfer by surface water or air	396	77	90	18	553
Accumulation in the Netherlands					
Acidification	92	94	99		
Eutrophication				89	726
Total destination	748	288	189	128	1 481

Source: Statistics Netherlands (1999).

3.86 The borderline problems between products and residuals and between products and natural resources were noted above. Similarly, the borderline between the national territory and the rest of the world may vary or be ignored in some studies. For example, for the contribution of a particular economy to global warming, it may be of interest to know the total extent of emissions without necessarily distinguishing how much is expelled to the national environment and how much elsewhere.

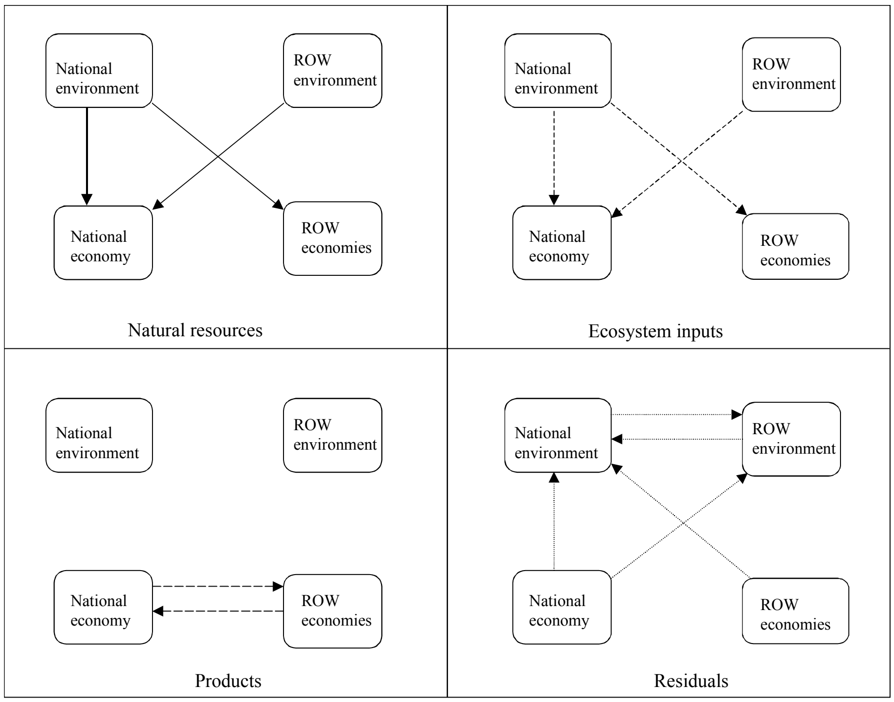
4. Types of flows

3.87 The next stage in preparing physical accounts is to identify which flows of which substances are to be included.

Flows of natural resources

3.88 All natural resources originate in the environmental sphere. Some remain there and so do not enter the physical flow accounts even though they should be recorded in stock levels. Those that are drawn into the economy become immediately transformed into products; that is, they exist within the context of a market that puts a monetary value on them. This is also the case in principle for resources harvested for own account use, for example, fuelwood collected by households, extracted of construction materials and abstracted water, even though in practice valuation may be difficult. Because natural resources are converted to products when they enter an economy, few natural resources are shown as entering the national economy from another country's environment directly; such resources are generally routed through the originating country's economy and are shown under imports of products not of natural resources. One exception is fish: non-residents may be entitled to fish in national waters but the catch never enters the national economy. Another involves extraction of water from a jointly owned catchment area or watercourse. Flows of natural resources are shown schematically in the upper left quadrant of Figure 3.3.

Figure 3.3. Scope of physical accounting



Flows of ecosystem inputs

3.89 Like natural resources, ecosystem inputs flow from the environment to the economy. The largest and most obvious flows are those from the national environment to the national economy. Other flows include the consumption of ecosystem inputs by resident producers operating outside their national territory, for example, international transport carriers and tourists. Flows relating to ecosystem inputs are shown schematically in the upper right quadrant of Figure 3.3.

Flows of products

3.90 As long as we are considering only those flows that cross either the boundary demarcating economy and environment or that demarcating nation and rest of the world, the only product flows to be recorded are those that comprise imports and exports, that is, flows between the national economy and rest of the world economies or vice versa. These flows are shown schematically in the lower left quadrant of Figure 3.3.

Flows of residuals

3.91 There are three classes of residuals flows to be captured.[10] The largest and most significant flows are from the national economy to the national environment. In the case where net residual flows are smaller than gross residual flows because of treatment or recycling prior to disposal, it is important that only the net residual flows be recorded as the economy to environment flow. It is thus important to have a comprehensive description of the activities of waste collection, recycling and waste treatment (as, for example, incineration or wastewater treatment).

3.92 Second, the accounts capture part of the discharge from production that is expelled directly into a different environment. These sorts of flows were discussed in relation to the boundary with the rest of the world.

3.93 The last type of residual flow is the transmission of residuals from one environmental sphere to another by natural mechanisms such as air currents or flowing water bodies. These also need to be counted in calculating total flows to and from the national environment. Cross–border pollution transfers are important for determining the total net accumulation of residuals in the national environment and are especially relevant for pollutants related to environmental degradation problems that are of a non-global nature. This has an important implication for valuation discussed in chapter IX. The physical flow accounts show that environmental damages generated by the national economy may differ from damages suffered by residents.

3.94 All three types of residual flows are shown schematically in the lower right quadrant of Figure 3.3.

C. Basic supply and use tables for physical flows

3.95 In discussing the boundary between the economy and the environment, the concept of three sorts of economic activities - production, consumption and capital accumulation - was introduced. Each of these involves products - the goods and services that are made by and consumed within the economy. Products that are consumed within the period in which they were created either become other products (intermediate consumption) or are transferred back to the environment as residuals. Products that are consumed over a period of time or at a future point in time are treated as capital accumulation.

3.96 The supply and use tables set out in the present section include details of the flows of products within the economy and their relation to the absorption of natural resources and ecosystem inputs as well as the generation of residuals. Introducing the flows of products within the economy and the three types of economic activities requires an extension to the areas of origin and destination for the four types of flows. This is provided in Table 3.3. Hidden flows that remain within the environment are not included in this table.

3.97 The question of the identification of different economic activities is considered first and the elaboration and disaggregation of the different types of flow accounts follow.

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[10] As noted above, the small flows of residuals that can occur between the environment and the economy (when, for example, spilled oil from an oil tanker disaster is cleaned up) are not included in this exposition.

Table 3.3. Origin and destination of flows in the physical supply and use tables

Type of flow	Origin	Destination
Natural resources	*Environmental sphere* National environment Rest of the world environment	*Economic sphere* Intermediate consumption Final consumption *Rest of the world economies*
Ecosystem inputs	*Environmental sphere* National environment Rest of the world environment	*Economic sphere* Intermediate consumption Final consumption *Rest of the world economies*
Products	*Economic sphere* Output from industries *Rest of the world economies* Imports	*Economic sphere* Intermediate consumption Capital formation Final consumption *Rest of the world economies* Exports
Residuals	*Economic sphere* Industries Households *Rest of the world economies* *Environmental sphere* National environment Rest of the world environment	*Economic sphere* Intermediate consumption (scrap and recycling) Capital formation (landfill) *Environmental sphere* National environment Rest of the world environment

1. Identifying economic activities

Products and the environment

3.98 Neither capital formation nor consumer durables nor are fully consumed in the period in which they are created but remain in the economy as a form of accumulation. Accumulation in physical accounts is measured quite differently than in monetary accounts. In physical accounts, an item remains in the accumulated stock until it is disposed of, all at once, at the point of retirement. This contrasts with the money value of an asset which declines over its lifetime. Also, whereas in monetary accounts consumer durables are recorded as being consumed immediately upon acquisition, in physical accounts this is not so: once again, they remain in the stock of accumulated material until disposed of.

3.99 In physical accounts, the disposal of products and of capital accumulation has many more ramifications than the simple loss of monetary value. All goods, whether for consumption or accumulation, have ultimately to be disposed of. Treatment plants may be able to extract some of the initial residuals for reprocessing and recycling. The remaining residuals typically go to landfill sites. In the physical accounts, this is accounted for as absorption of residuals by capital formation, though it would be difficult to argue that it always constitutes land improvement, which this treatment suggests. Landfill sites (strictly speaking, licensed and controlled landfill sites) thus become a sort of capital accumulation in themselves and may give rise to the generation of residuals in turn either as methane or as leaching into water sources, for example.

Products and the rest of the word

3.100 In principle, use of products by embassies etc. located in the national economy should be treated as exports and consumption in the country's own embassies abroad should be treated as imports. An allowance for this is made in monetary terms in the balance-of-payments calculations and in the national accounts, but it may not be possible to make a similar adjustment in physical terms. Any error caused by this would normally be well within the margin of error for the whole exercise.

3.101 In a manner that is similar to that for embassies, adjustments for the purchase of products by tourists in the national economy and by nationals abroad are made in monetary terms and should be made also in physical terms. In countries where net tourism is significant, it may be important to make an adjustment for this not just in monetary but also in physical terms. This is especially important for fuel in the case of countries with land borders to which many tourists come using their own cars or in home-country buses.

Products within the economy

3.102 The uses of products to satisfy consumer needs and for capital formation have been referred to earlier. The other major use of products within the economy is in the production of other products in the same period. This use is referred to as intermediate consumption. However, the information available on intermediate consumption introduces a complexity into the classification schemes to be used in accounting for products throughout the economy.

3.103 Although any data on the composition of intermediate consumption (use) will show product detail, the production (supply) data is available only for producers. At the most detailed level, the unit involved in production is the establishment. For all but the largest firms, there is only one establishment in an enterprise. Both establishments and enterprises can be aggregated to the level of industries. While the difference between establishment and enterprise is important to national accountants, the term "production unit" is used here to mean either of these (as relevant to the context) and the term "industry" is used to mean a group of either.

3.104 The supply table and that part of the use table relating to intermediate consumption include an industry dimension on one axis and a product dimension on the other. Industries should be classified according to the International Standard Industrial Classification of All Economics Activities (ISIC) and products according to the Central Product Classification (CPC). Information on household consumption should be disaggregated according to the Classification of Individual Consumption According to Purpose (COICOP). Government consumption is not shown in the examples of the physical flow accounts since it is assumed that government production is articulated along with other industries. However, in the national accounts of some countries, the details of government inputs may be recorded as final and not as intermediate consumption. In these cases, the physical accounts should record government consumption by purpose (see Classification of the Functions of Government (COFOG)) in a way that is similar to consumption by households (see COICOP).

3.105 Not only is production data classified according to industries rather than according to products, but the technical information on residual generation is usually related to industries also. This is because the generation of residuals depends not just on the products consumed but also on the processes involved, which tend to be industry-specific. This use of different classifications for source and destination is normal in the compilation of supply and use tables, even though for many analyses it is convenient to have so-called symmetric tables where supply and use are both shown either of products and by products or of industries and by industries. For products it is possible, however, by the use of a number of assumptions, to transform the asymmetric information in supply and use tables into symmetric input-output tables which use the same classification for the same sorts of units for both origin and destination. This transformation of the in the information in supply and use tables to symmetric information marks a subsequent step in the analysis of flows and the construction of derived accounts as discussed in chapter IV.

3.106 Although the tables may show *k* resources and *m* products being absorbed by *n* industries to produce *p* residuals, not all the technical coefficients linking these factors are known in advance. To a certain degree the economic sphere and the environmental sphere of the supply and use tables could be regarded as "black boxes". We know that flows are going in and flows are coming out, but we do not know (or at least cannot a priori describe) what is going on inside the black box or what the connection between the ingoing and outgoing flows are. Such a description is reserved for some of the derived accounts and analysis. In some cases, though, more detailed information for the economic sphere and the environmental sphere exists. For the environmental sphere, it is often known into which media (air, water, land) residual flows are discharged. In these cases the destination side can be specified in more detail by the introduction of new row entries.

3.107 The physical supply and use tables shown in the following sections are denominated in physical units of account but not in money terms. The figures presented in the tables are purely illustrative and relate to a fictional country called SEEAland. Tables throughout the handbook showing the SEEAland data set as the source are internally consistent so as to show the interconnections across different subject areas. In the physical accounts, all data are denominated in millions of metric tons though sometimes three decimal places are shown to illustrate the occurrence of small but possibly important entries at the level of thousands of metric tons. Although other units of account may be more appropriate for particular material flows, the comprehensibility of the framework is better illustrated by the introduction of a single unit.

3.108 Supply and use tables are developed for each type of flow. Natural resources and ecosystem inputs come from the environment and go to industries, consumption or (in limited cases) the rest of the world. (Capital formation and exports use only products.) Products come from industries or the rest of the world (imports) and are used by industries, capital formation, consumption or exports. Residuals are generated by industry, capital formation and consumption and are either retained within the economy as recycled products or in landfill sites or "used" by, that is, discharged into, the environment. Once these three pairs of tables have been elaborated, they are then assembled into a general matrix presentation as the groundwork for further development and analysis.

2. Use table for natural resources

3.109 Natural resources are recorded at the moment that they are withdrawn from the environment. By definition, the economic sphere does not contribute to the output of natural resources. The description of resource flows focuses purely on the use side.

3.110 Natural resources are used mainly for production and consumption. No uses of natural resources are identified in relation to capital formation. Only in special cases such as fishing is there use by the rest of the world. Once the extraction has taken place, natural resources appear in the accounts as product flows. Therefore, inventory changes and exports of, for example, coal, are recorded as exports of products taking place entirely in the economic sphere. These flows are shown schematically in Figure 3.4. Table 3.4 offers examples of numerical flows in detail.

3.111 Resources are classified according to the classification developed in annex I[11] and further elaborated in annex II. The assets of interest for physical flow accounting are mainly the following:

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[11] The rationale and elaboration of this classification appears in chapter VII.

EA.11 Mineral and energy resources

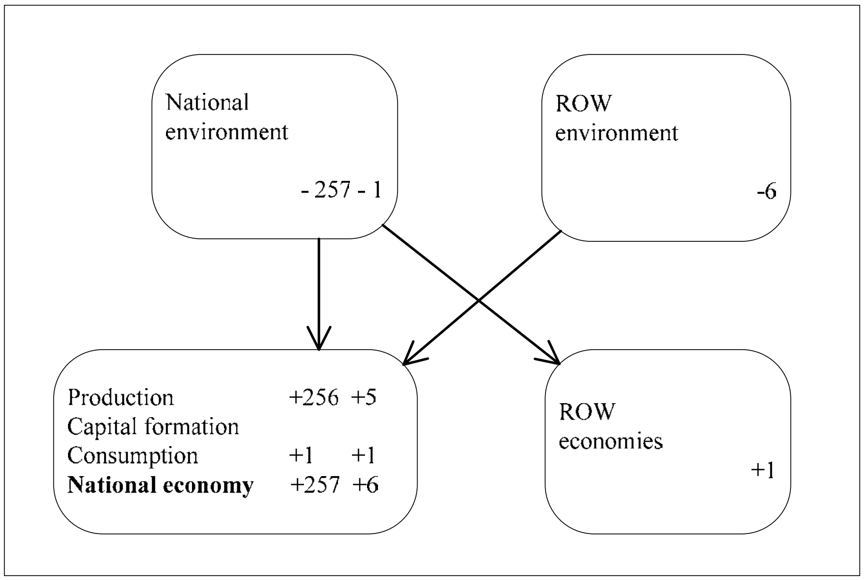
EA.12 Soil resources

EA.13 Water resources

EA.14 Biological resources (non-cultivated only)

Figure 3.4. Natural resource flows

Millions of tons



Source: SEEAland data set.

3.112 Land is not included because flows are not relevant. In the example presented in Table 3.4, subsoil assets are shown disaggregated to oil, gas and other; non-cultivated biological assets to wood, fish and other. Non-cultivated biological assets are split into wood, fish and other. The other category shown is water.

3.113 In general, it is not difficult to identify the industry concerned with natural resource extraction because there are only a limited number of industries involved. The most obvious industries, classified according to ISIC, are:

01 Agriculture, hunting

02 Forestry

05 Fishing

1 Mining

41 Water supply

3.114 In the sample tables, industries are aggregated into three groups; agriculture, fishing and mining (which together use most of the subsoil assets and biological resources); manufacturing, electricity and construction (which absorbs the remaining subsoil assets); and services. Consumption is broken down between own account transport and other.

Table 3.4. Use (destination) table for natural resources

Millions of tons

	Destination (use by):	Production				Consumption			ROW	Total
		Agriculture, fishing, and mining	Manufacturing, electricity etc. and construction	Services	Total	Own account transport	Other consumption	Total	Non-residents operating in the national territory	
		I1	I2	I3	I	C1	C2	C	X1	
	National resources									
	Subsoil assets:									
N1	Oil	38			38			0		38
N2	Gas	27			27			0		27
N3	Other	118	55		173			0		173
	Non-cultivated biological assets:									
N4	Wood	7	1		8		1	1		9
N5	Fish	1			1			0	1	2
N6	Other		2		2			0		2
N7	Water	1	6		7			0		7
	Total national natural resources	**192**	**64**	**0**	**256**	**0**	**1**	**1**	**1**	**258**
	ROW resources									
	Non-cultivated biological assets:									0
N5	Fish	4			4			0		4
N7	Water		1		1		1	1		2
	Total ROW natural resources	**4**	**1**	**0**	**5**	**0**	**1**	**1**		**6**
	Total natural resources	**196**	**65**	**0**	**261**	**0**	**2**	**2**	**1**	**264**

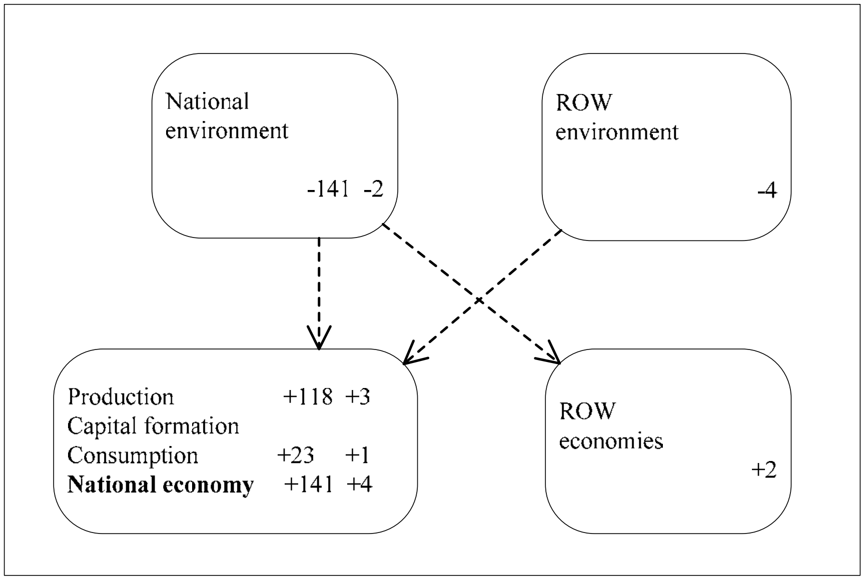
Source: SEEAland data set.

3. Use table for ecosystem inputs

3.115 Only a limited number of ecosystem inputs may be included, such as the water and oxygen required to support combustion and non-product substances required for cultivated biomass growth. These are drawn from the asset classification headings EA.32, Aquatic ecosystems, and EA.33, Atmospheric systems. The flows are shown schematically in Figure 3.5 and numerically in Table 3.5. All industry groups and both categories of consumption absorb oxygen for combustion. The flows between the national economy and the rest of the world environment, or between the rest of the world economy and the national environment, relate mainly to this use of oxygen for combustion drawn from a foreign environment by national vessels operating outside their own territory.

Figure 3.5. Ecosystem input flows

Millions of tons



Source: SEEAland data set.

Table 3.5. Use (destination) table for ecosystem inputs

Millions of tons

Destination (use by):	Production				Consumption			ROW	Total
	Agriculture, fishing and mining	Manufacturing, electricity etc. and construction	Services	Total	Own account transport	Other consumption	Total	Non-residents operating in the national territory	
	I1	I2	I3	I	C1	C2	C	X1	
National ecosystem inputs									
E1 Water	2			2		1	1		3
E2 Air, oxygen and nitrogen	13	81	22	116	10	12	22	2	140
Total national ecosystem inputs	**15**	**81**	**22**	**118**	**10**	**13**	**23**	**2**	**143**
ROW ecosystem inputs									
E2 Air, oxygen and nitrogen			3	3	1		1		4
Total ecosystem inputs	**15**	**81**	**25**	**121**	**11**	**13**	**24**	**2**	**147**

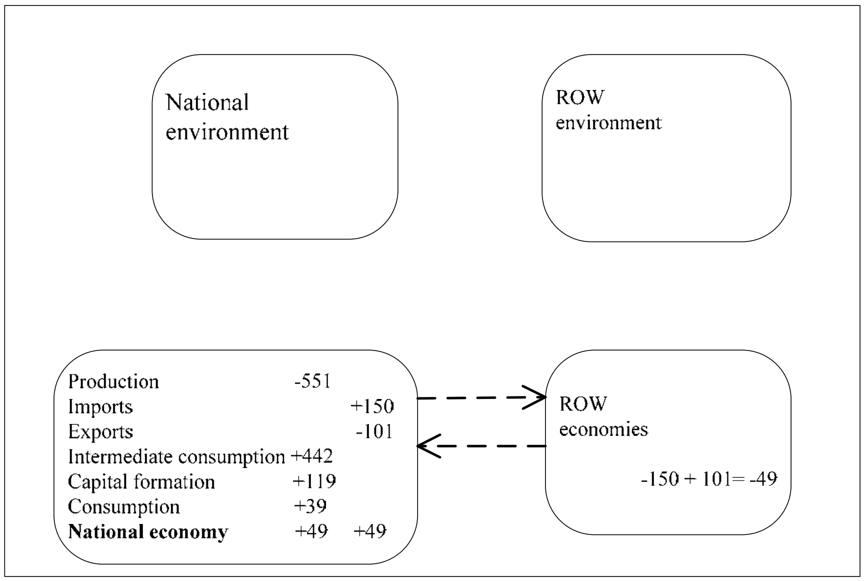
Source: SEEAland data set.

4. Supply and use tables for products

3.116 Figure 3.6 provides a schematic overview of the supply and use tables for products. The only flows coming into and leaving the national economy are those for imports and exports. Flows within the economy indicate that the balance from the rest of the world can also be written as the difference between total supply of products (551) and the uses other than exports (intermediate consumption [442], capital formation [119] and consumption [39]). Another way of expressing this is to say that if all the entries for the flows within the economy are aggregated there will be no net flows left. This is simply another expression of the identity stating that total supply of products (production plus imports) must be equal to the total use (intermediate consumption, final consumption, capital formation and exports).

Figure 3.6. Product flows

Millions of tons



Source: SEEAland data set.

3.117 Table 3.6 and Table 3.7 show the supply and use of all products. Sometimes production and import information is available in quantity terms directly; at other times, value figures must be decomposed into average prices and physical units. In general, only the material flows of specific product groups can be estimated directly in full detail. The product groups for which this is most likely are those representing flows of fairly homogeneous material such as fuels, metals, plastics and paper. For other product groups, rougher indirect estimate procedures are likely to be the only ones available.

3.118 When physical quantities have to be determined by dividing the value data by price indices, consideration has to be given to any adjustment that may have been made to the prices to allow for quality changes. In economic statistics in general and national accounts information in particular, the volume figures are not entirely synonymous with physical quantities. If an apparent price increase of 5 per cent accompanies an increase in quality deemed to be worth 2 of these 5 percentage points, then a national accountant will say that the volume has increased by 2 per cent even though the physical dimensions remain the same. It is a measure of volume of the same quality that is required for national accounts and not just a purely physical measure. For physical flow accounts, however, in principle no such quality adjustment should be made and this may necessitate "removing" or otherwise trying to adjust back so as to remove any quality effects previously built into the price indices.

Table 3.6. Supply (origin) table for products

Millions of tons

Origin (supply by):	Industries				ROW	Total
	Agriculture, fishing and mining	Manufacturing, electricity etc. and construction	Services	Total industries	Imports	
	I1	I2	I3	I	M2	
P1 Animal and vegetable products	66	49	1	116	16	132
P2 Stone, gravel and building materials	112	163		275	13	288
P3 Energy	65	59		124	95	219
P4 Metals, machinery etc.		10		10	10	20
P5 Plastic and plastic products		2		2	2	4
P6 Wood, paper etc.	7	7		14	1	15
P7 Other commodities		9	1	10	13	23
All products	**250**	**299**	**2**	**551**	**150**	**701**

Source: SEEAland data set.

Table 3.7. Use (destination) table for products

Millions of tons

Destination (use by):	Industries				Consumption			Capital	ROW	Total
	Agriculture, fishing, and mining	Manufacturing, electricity etc. and construction	Services	Total industries	Own account transport	Other consumption	Total consumption	Capital formation	Exports	
	I1	I2	I3	I	C1	C2	C	CF	X2	
P1 Animal and vegetable products	23	60	4	87		16	16	3	26	132
P2 Stone, gravel and building materials	12	148	2	162		2	2	114	10	288
P3 Energy	34	101	20	155	7	10	17	0	47	219
P4 Metals, machinery etc.		11		11	1		1	1	7	20
P5 Plastic and plastic products		2		2					2	4
P6 Wood, paper etc.		7	4	11		1	1		3	15
P7 Other product groups	5	8	1	14		2	2	1	6	23
All products	**74**	**337**	**31**	**442**	**8**	**31**	**39**	**119**	**101**	**701**

Source: SEEAland data set.

3.119 In the examples, data are shown for seven products or groups of products. The industries shown are the same as those in the table for natural resource flows.

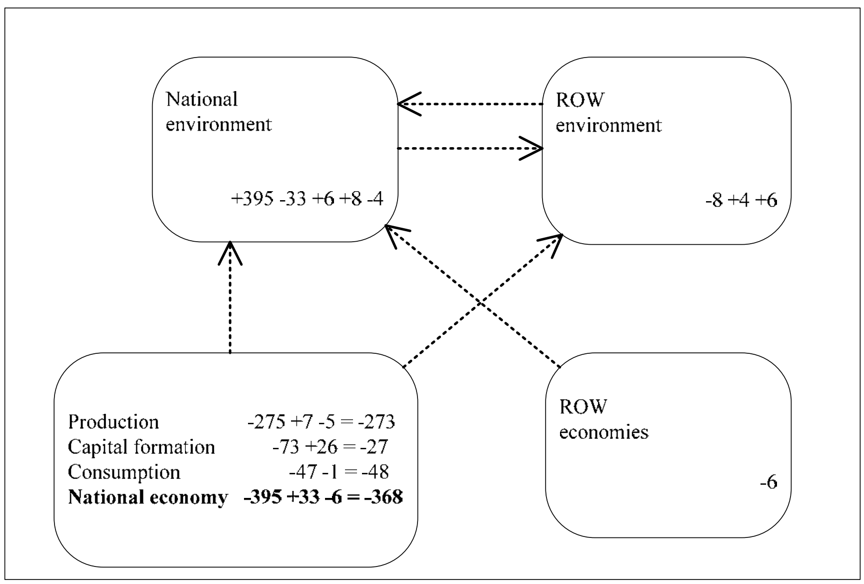
3.120 Tables such as these can be compiled for specific sets of product groups that are of particular interest. For example, it is possible to focus on the supply and use table for specific toxic chemicals or energy products and omit information on the flows of other products. Further, the supply and use table for one or more products can be transformed into supply and use tables for energy (calorific values) or chemical elements (nitrogen, say) by using technical information on the content of the products (for example, percentages of nitrogen in different chemicals, food etc.). Physical supply and use tables for energy products are interesting for the analysis of energy savings/efficiency analysis as well as for the construction of supply tables for energy-related residuals, such as CO_2, SO_2, NO_x etc. The practical aspects oft he construction of energy and related residual accounts are further illustrated in chapter IV.

5. Supply and use tables for residuals

3.121 Residuals flow into the environmental sphere (air, water, land) from various parts of the economic sphere: production (industries), capital (leakage from landfill sites) and consumption. In addition, some residuals are generated by resident units beyond the national territory and some residuals are generated locally by non-residents. Residuals carried by environmental media between the national environment and the rest of the world environment are also shown in supply and use tables for residuals. These flows are shown schematically in Figure 3.7.

Figure 3.7. Residual flows

Millions of tons



Source: SEEAland data set.

3.122 The gross output of residuals is equal to the output of residuals generated in the economy, including the amount of residuals that may be reabsorbed in a second stage owing to recycling or waste (water) treatment.

Generation of residuals

3.123 Table 3.8 shows the generation of gross residuals by the economy. The top part shows the residuals emitted to the national environment. The lower part shows emission by national transport companies operating abroad and households on holiday abroad as tourists. This is one table where flows can be read in thousands of (kilo) tons rather than in million of tons. Although some flows are quite small in absolute terms, they may be significant in terms of their impact on the environment or on human health.

3.124 Residual outputs by industries are classified as before according to ISIC and shown in the same three groups in these tables. The direct emission of residuals from households is also shown as before, with a distinction between own account transport and other consumption.

Table 3.8. Supply (origin) table for residuals

Millions of tons

Origin (supply by):	Industries				Consumption			Capital	ROW			Total
	Agriculture, fishing and mining	Manufacturing, electricity etc. and construction	Services	Total Industries	Own account transport	Other consumption	Total consumption	Capital formation	Non-residents on the national territory	Cross-boundary environmental inflows	Total ROW	
	I1	I2	I3	I	C1	C2	C	CF	M1	M3	M	
To air:												
R1 CO_2	19.020	111.398	29.930	160.348	16.908	25.080	41.988	0.990	4.172		4.172	207.498
R2 N_2O	0.007	0.042	0.012	0.061	0.003	0.004	0.007		0.001		0.001	0.069
R3 CH_4	0.073	0.452	0.125	0.650	0.004	0.020	0.024	0.477	0.001		0.001	1.152
R4 NO_X	0.061	0.275	0.151	0.487	0.084	0.026	0.110		0.025	0.117	0.142	0.739
R5 SO_2	0.023	0.139	0.030	0.192	0.003	0.001	0.004		0.001	0.087	0.088	0.284
R6 NH_3	0.020	0.123	0.038	0.181		0.007	0.007			0.019	0.019	0.207
R7 Other	0.010	0.061	0.015	0.086		0.012	0.012			0.002	0.002	0.100
To water:												
R8 P	0.070	0.020	0.004	0.094		0.011	0.011	0.003	0.001	0.014	0.015	0.123
R9 N	0.590	0.210	0.098	0.898		0.117	0.117	0.024	0.006	0.323	0.329	1.368
R10 Other	0.030	0.021	0.006	0.057		0.021	0.021	0.001	0.001	0.003	0.004	0.083
Solid waste:												
R11 Mining waste	7.233	2.320		9.553								9.553
R12 Other	8.103	71.619	22.929	102.651	0.100	5.060	5.160	71.100	1.548	7.656	9.204	188.115
Total	**35.240**	**186.680**	**53.338**	**275.258**	**17.102**	**30.359**	**47.461**	**72.595**	**5.756**	**8.221**	**13.977**	**409.291**
To ROW territory												
To air:												
R1 CO_2			4.569	4.569	0.739		0.739					5.308
R4 NO_X			0.010	0.010	0.004		0.004					0.014
R5 SO_2			0.008	0.008	0.002		0.002					0.010
Total			**4.587**	**4.587**	**0.745**		**0.745**					**5.332**
Total residuals	**35.240**	**186.680**	**57.925**	**279.845**	**17.847**	**30.359**	**48.206**	**72.595**	**5.756**	**8.221**	**13.977**	**414.623**

Source: SEEAland data set.

3.125 Residuals should in all cases be attributed to the economic activity directly responsible for the residual generation. Thus, pollution generated from electricity production should be attributed to electricity suppliers and not to the electricity consumers. The attribution of pollution to final users or products should be considered an analytical continuation of accounting. The direct recording of residual flows is important for accurate and consistent connection of residual flows to material throughputs and economic transactions, and hence for linking pollution-generation to final use.

Classification and data issues

3.126 Connecting residual flow data to national accounts data will usually result in significant modification of the scope of the original emissions data. One particular point of concern in this respect is the delimitation problem with respect to international transport and tourism (see also Gravgaard Pedersen (1998)). Regular emission inventories usually cover emissions within the geographical territory of a country and do not correspond exactly to the coverage of the economy of resident units due to the existence of international transport. In order for the environmental consequences of these activities to be taken into account in the SEEA, it is necessary to allow for flows of emissions by non-resident units in the national environment and emissions by resident units outside the national environment. This means that in the SEEA, the output generated by international transport services such as airline and shipping activities is attributed to the country where the operator resides.

3.127 This is not the case in the IPCC (Intergovernmental Panel on Climate Change) conventions on global warming emissions which specify that pollution from international transport is not attributed to individual countries. A greenhouse gas emission account based on the SEEA will deviate in this respect from the methodology laid down by IPCC. Equally, emission inventories will usually record emissions that broadly correspond to the (national) geographical territory, including pollution from cars registered in foreign countries.

3.128 It is quite likely that different emission estimates may be compiled for different types of uses in one country. Sometimes emissions will be adjusted for incidental changes such as differences in the average annual temperatures. In other cases, emission figures estimated according to a geographical criterion will be used alongside figures estimated according to the resident criterion. A simple way to avoid misunderstandings is to publish these figures together with straightforward bridge tables that clearly explain these differences. An example is given in Table 4.8. Such tables are often published with the national accounts to explain differences in various income measures such as the difference between domestic product and national income.

Destination of residuals

3.129 The disposal of capital equipment and consumer durables forms part of the supply of residuals and is "used" by the economy in landfill sites. The output of residuals in the capital account consists of emissions such as leakage from landfills and infrastructure. The residuals shown in Table 3.8 as being generated in the rest of the world by transport enterprises and tourists are shown as having the rest of the world as their destination in Table 3.9.

Recycling

3.130 There are mainly two types of economic activities that may result in the absorption of residual flows within the economic system: recycling and waste (water) collection and treatment. Economic activities specifically involved in the recycling of material flows are "recycling" (ISIC 37) and "wholesale of other intermediate products, waste and scrap" (ISIC 5149). In principle, Table 3.9 could be subdivided into one table on waste collection and treatment and another table on recycling.

3.131 The main activity of recycling industries consists of the mechanical or chemical transformation of materials in order to make these usable again as industrial inputs. The activity of wholesale trade in waste and scrap is restricted to waste storage, sorting etc. and is one where goods are sold in the same condition in which they are acquired without undergoing any physical transformation other than sorting, and packaging. If any industry, recycling or wholesale, acquires inputs at zero (or near zero) cost, the inputs should be regarded as inputs of residuals. If the inputs for recycling have a positive price, then they should be treated as products and recorded as such.

3.132 Residuals for recycling typically follow one of two paths. Material that can be recycled without further handling, for example, paper, often passes through wholesalers to the user. Material that needs processing typically reaches the wholesaler only after it has been converted to "secondary raw material" by the processors.

Table 3.9. Use (destination) table for residuals

Millions of tons

Destination (use by):	Industries				Capital	ROW environment			National environment	Total
	Agriculture, fishing and mining	Manufacturing, electricity etc. and construction	Services	Total industries	Capital formation	Residents in ROW	Cross-border environmental outflows	Total		
	I1	I2	I3	I	CF	X1	X3	X	E	
From national territory										
From air:										
R1 CO_2									207.498	207.498
R2 N_2O									0.069	0.069
R3 CH_4									1.152	1.152
R4 NO_X							0.669	0.669	0.070	0.739
R5 SO_2							0.196	0.196	0.088	0.284
R6 NH_3							0.099	0.099	0.108	0.207
R7 Other							0.002	0.002	0.098	0.100
From water:										
R8 P			0.020	0.020			0.010	0.010	0.093	0.123
R9 N			0.115	0.115			0.543	0.543	0.710	1.368
R10 Other			0.010	0.010			0.002	0.002	0.071	0.083
Solid waste:										
R11 Mining waste									9.553	9.553
R12 Other	0.240	2.680	3.780	6.700	25.810		2.398	2.398	153.207	188.115
Total	**0.240**	**2.680**	**3.925**	**6.845**	**25.810**		**3.919**	**3.919**	**372.717**	**409.291**
From ROW territory										
From air:										
R1 CO_2						5.308		5.308		5.308
R4 NO_X						0.014		0.014		0.014
R5 SO_2						0.010		0.010		0.010
Total						5.332		5.332		5.332
Total	**0.240**	**2.680**	**3.925**	**6.845**	**25.810**	**5.332**	**3.919**	**9.251**	**372.717**	**414.623**

Source: SEEAland data set.

3.133 In the case where a wholesaler also processes residuals into usable material, special treatment in the accounts may be needed. Under national accounts conventions, wholesalers are not shown as acquiring and disposing of goods but only as adding a trade margin. The goods are shown as going directly from the producer to the user and do not feature as intermediate consumption of the wholesaler. It is desirable to vary this practice in respect of residual handling when the wholesaler acquires residuals and processes some part, leaving a smaller quantity remaining as residuals.

3.134 Another example of residuals retained in the economy is the collection and treatment of waste or wastewater by environmental services. The main purpose of these services is to reduce the environmental impact of residual flows, for example, by incineration of solid waste or purification of wastewater. Waste (water) treatment in these services will subsequently lead to different and hopefully less harmful types of residual outputs.

3.135 The controlled storage of waste on landfills or public infrastructure is shown as retention of residuals within the economy by capital and thus as an accumulation within the economic sphere. Only in the case of clean-up of residuals previously deposited in the environment is there a reabsorption of residuals by the economy. This may be the case for cleaning contaminated soil, cleaning up oil spills and so on.

Net emissions

3.136 The systematic recording of all residual inputs and outputs of recycling industries and other producers of environmental services requires that the gross residual flows for all other industries be recorded. This gross flow includes residuals remaining within the economic sphere as well as the any that re-enter the economic sphere owing to environmental clean-up activities. It also includes emissions generated by the economy in the environment of the rest of the world. In Table 3.10, the figures from the upper and lower part of Table 3.8 have been aggregated under gross emissions.

Table 3.10. Net emissions of selected residuals

Millions of tons

		To national environment									
		Gross emissions				Absorption by economy					
		Industries	Consumption	Capital	Total	Treated and reused by industries	Landfills	Total	**Total net emissions**	Emitted in the rest of the world	Net emissions to the national environment
R1-R7	Air emissions	166.592	42.897	1.467	210.956				210.956	5.332	205.624
R8	P	0.094	0.011	0.003	0.108	0.020		0.020	0.088		0.088
R9	N	0.898	0.117	0.024	1.039	0.115		0.115	0.924		0.924
R10	Other to water	0.057	0.021	0.001	0.079	0.010		0.010	0.069		0.069
R11	Mining waste	9.553			9.553				9.553		9.553
R12	Other solid waste	102.651	5.160	71.100	178.911	6.700	25.810	32.510	146.401		146.401
	All residuals	**279.845**	**48.206**	**72.595**	**400.646**	**6.845**	**25.810**	**32.655**	**367.991**	**5.332**	**362.659**

Source: SEEAland data set.

3.137 It is also helpful to have an accounting for net emissions by deducting the quantity of emissions that are absorbed into the economy for recycling as well as the quantity going to landfills. These data are shown in Table 3.9 and are deducted from gross emissions to yield net emissions. Again, it is interesting to note the quantity of the remaining net residuals that are absorbed by the national environment and the quantity that flow to the rest of the world environment. Table 3.10 shows net emissions and how these divide between the national and rest of the world environment. These calculations may be performed in aggregate, to show the net effect on the national environment, or may be related to individual pollutants.

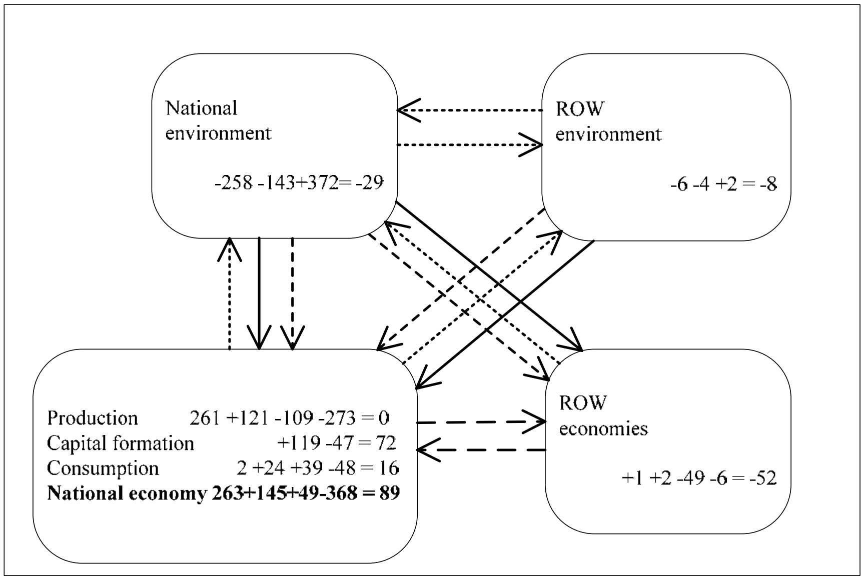
3.138 The treatment of pollution can be taken care of directly at the polluting establishment or, in some cases, handed over to specific waste treatment facilities which usually belong to the environmental services industry. When the direct contribution to residuals is calculated, the accounts show favourable results for those industries that have internal treatment facilities in comparison with those industries that hand over their residual flows to specific waste treatment plants. For this purpose, it might be useful to identify for each industry, the shares of residual flows that are externally treated. However, since, in practice, it may be difficult to obtain this information, often a gross approach will be preferable if transactions between establishments are involved, while a net approach will be preferable when residuals are processed or eliminated within the establishments themselves.

6. The complete system of physical flow accounts

3.139 All the relationships for the different physical flows can be brought together as shown in Figure 3.8. In the entries for the national economy, the counterpart entries for imports and exports have been used (that is, the first column within the national economy box in Figure 3.6 has been used but with production (-551) and intermediate consumption (442) aggregated to a net figure of 109). This shows that the accumulation by production is exactly zero and that the total accumulation in the economic sphere is accounted for entirely by the accumulation of fixed capital or consumer durables.

Figure 3.8. Illustration of total flows described by the supply and use table

Millions of tons



Source: SEEAland data set.

3.140 The system shows a comprehensive overview of the physical economy. Its comprehensiveness can only be guaranteed when all flows are accounted for in similar mass units. Again, it must be emphasized that other units may be more relevant in the analysis of specific flows. Nor should the tables be interpreted as the ultimate goal of physical flow accounting: they are to be regarded more as an illustration of possibilities and an understandable presentation of the overall material balance of a national economy. It is possible to analyse the overall material balance only if all supply and use tables are constructed and combined.

3.141 A comprehensive system of physical accounts including natural resources, products and residuals can also be constructed for specific types of material. One obvious example that has been widely applied in various countries is a comprehensive system of energy accounts. These accounts may include natural resource extraction activities such as oil and gas mining, transformation of energy into different types of energy products and finally the consumption of these products which usually leads to the output of combustion-related residuals such as emissions of CO_2, SO_2 and so on. The construction of such a system is further illustrated in chapter IV. Another pertinent example in this respect is the comprehensive system of accounts for timber and forest products described in section D below.

3.142 One way to bring together the tables underlying Figure 3.8 is to use a matrix format. By convention, all the use tables are shown along the rows of the matrix and all the supply tables along the columns. Although there are different classifications used for natural resources, products, industries and residuals, it is possible, since they are consistent across the tables, to set up the matrix so that the rows and columns match one by one.

3.143 The information in Table 3.4 to Table 3.9 inclusive is combined in matrix form and portrayed schematically in Table 3.11 and in detail in Table 3.12.

3.144 The data in Figure 3.1 to Figure 3.7 can be read off from Table 3.11. The data for natural resources appear in rows 6 and 7; those for ecosystem inputs in rows 8 and 9. The entries in rows and columns 1 to 5 correspond to the diagram for products (Figure 3.6) and the identity between total supply and total use of products portrayed in row and column 1. The data in rows and column 10 and 11 relate to residuals.

3.145 Table 3.11 highlights the fact that, only in the case of products, is total supply equal to total use. For natural resources, there is a net inflow from the environment to the economy and for residuals a net flow in the opposite direction. Recalling the principle stated at the beginning of this chapter, namely, that total inflows and outflows must balance, it is therefore possible to use the last column of Table 3.11 to show the net accumulation in either the economy (shown as positive) or in the environment (shown as negative). Note that the flows to the environment take no account of the natural assimilative capacity so that total accumulation in the environment may be less than that apparently shown.

3.146 Table 3.12 shows both the advantages and disadvantages of matrix presentation: it is a very compact and illustrative means of illustrating the interactions within the economy and between the economy and the environment. Because every element sits at the intersection of a row and a column, it is possible to see immediately its origin (from the row) and destination (to the column). For expository purposes and to have an overview of the system, this is extremely valuable. However, it can be seen that, in order to keep the table to a reasonable size, some aggregation of the residual rows and columns has been made.

3.147 For practical presentation, therefore, it is common to divide the information into a supply part and a use part which eliminate the empty cells in Table 3.12 and where each part has the same row and column identifiers. The supply table in Table 3.13 is formed by taking column 1 for products and columns 10 and 11 for residuals from Table 3.12 and transposing these so that each column appears as a row. In the transposed tables, the (new) columns are dominated by the entries that appear in rows 2, 3, 4 and 5 of Table 3.12 . The use table in Table 3.13 is composed of the remaining columns of Table 3.12 (columns 2 to 9) in their original, untransposed format. This gives the parallel between the two parts of Table 3.13 where the columns in both parts now relate to industries, final consumption, capital and flows with the rest of the world. (Columns 6-9 are not often shown in Table 3.12 as they are empty by definition, since natural resources and ecosystem inputs flow only from the environment to an economy and not from an economy to the environment.) At the end of the supply table, a set of balancing items in a final row shows the net material accumulation in the national economy, calculated as the excess of use over supply for each column/use category. A final column in the use table shows the net withdrawals from the environment, also calculated by deducting supply from use, this time by row/supply categories. Because accumulation can occur in the economy only if there are net withdrawals from the environment, these two balancing items are equal. Together they represent the entries in the material balance column in Table 3.12.

Table 3.11. Matrix representation of physical flows

Million of tons

		Economy					Residuals		Material balance	Total use
		1. Products	2. Industries	3. Consumption	4. Capital	5. ROW (destination)	10. National destination	11. ROW destination		
Economy	1. Products		Products used by industry 442.000	Products used for consumption 39.000	Products used for capital 119.000	Products used by ROW (exports) 101.000				701.000
	2. Industries	Products supplied by industry 551.000					Residuals generated by industry 275.258	Residuals generated by industry in ROW 4.587		830.845
	3. Consumption						Residuals generated by consumption 47.461	Residuals generated by consumption in ROW 0.745	Net material accumulation by consumption 16.794	65.000
	4. Capital						Residuals generated by capital 72.595		Net material accumulation by capital 72.215	144.810
	5. ROW (origin)	Products supplied by ROW (Imports) 150.000					Residuals generated by non-residents 5.756		Net material accumulation of products by ROW economy - 51.756	104.000
Natural resources	6. National environment		Natural resources supplied to industry 256.000	Natural resources supplied to consumption 1.000		Nat. resources extracted by ROW 1.000			Net accumulation of natural resources in the national environment - 258.000	0
	7. ROW origin		Natural resources supplied to industry 5.000	Natural resources supplied to consumption 1.000					Net accumulation of natural resources in the ROW - 6.000	0
Ecosystem inputs	8. National environment		Ecosystem inputs to industry 118.000	Ecosystem inputs to consumption 23.000		Ecosystem inputs to ROW economy 2.000			Net accumulation of ecosystem inputs in the national environment - 143.000	0
	9. ROW origin		Ecosystem inputs to industry 3.000	Ecosystem inputs to consumption 1.000					Net accumulation of ecosystem inputs in the ROW - 4.000	
Residuals	10. National origin		Residuals reabsorbed by production 6.845		Waste to landfill sites 25.810			Cross-boundary outflows 3.919	Net accumulation of residuals in the national environment 372.717	409.291
	11. ROW origin						Cross-boundary residual inflows 8.221		Net accumulation of residuals by ROW 1.030	9.251
Total supply		701.000	830.845	65.000	144.810	104.000	409.291	9.251	0.000	2 264.197

Source: SEEAland data set.

Table 3.12. Full matrix presentation of the physical flows between the economy and the environment

Millions of tons

				Economy																
				1. Products								2. Industries				3. Consumption			4. Capital	5. ROW (destination)
				P1	P2	P3	P4	P5	P6	P7	**P**	I1	I2	I3	**I**	C1	C2	**C**	**CF**	**X2**
Economy	1. Products	P1	Animal and vegetable products									23.000	60.000	4.000	**87.000**		16.000	**16.000**	**3.000**	**26.000**
		P2	Stone, gravel and building materials									12.000	148.000	2.000	**162.000**		2.000	**2.000**	**114.000**	**10.000**
		P3	Energy									34.000	101.000	20.000	**155.000**	7.000	10.000	**17.000**	**0.000**	**47.000**
		P4	Metals, machinery etc.										11.000		**11.000**	1.000		**1.000**	**1.000**	**7.000**
		P5	Plastic and plastic products										2.000		**2.000**					**2.000**
		P6	Wood, paper etc.										7.000	4.000	**11.000**		1.000	**1.000**		**3.000**
		P7	Other product groups									5.000	8.000	1.000	**14.000**		2.000	**2.000**	**1.000**	**6.000**
			All products									**74.000**	**337.000**	**31.000**	**442.000**	**8.000**	**31.000**	**39.000**	**119.000**	**101.000**
	2. Industries	I1	Agriculture, fishing and mining	66.000	112.000	65.000	0.000	0.000	7.000	0.000	**250.000**									
		I2	Manufacturing, electricity and construction	49.000	163.000	59.000	10.000	2.000	7.000	9.000	**299.000**									
		I3	Services	1.000	0.000	0.000	0.000	0.000	0.000	1.000	**2.000**									
		I	**Total industries**	**116.000**	**275.000**	**124.000**	**10.000**	**2.000**	**14.000**	**10.000**	**551.000**									
	3. Consumption	C1	Own account transport																	
		C2	Other consumption																	
		C	**Total consumption**																	
	4. Capital	**CF**	**Capital formation**																	
	5. ROW (origin)	**M2**	**Imports of products**	**16.000**	**13.000**	**95.000**	**10.000**	**2.000**	**1.000**	**13.000**	**150.000**									
Natural resources	6. National environment		Subsoil assets																	
		N1	Oil									38.000			**38.000**					
		N2	Gas									27.000			**27.000**					
		N3	Other									118.000	55.000		**173.000**					
			Non-cultivated biological assets																	
		N4	Wood etc.									7.000	1.000		**8.000**		1.000	**1.000**		
		N5	Fish									1.000			**1.000**					**1.000**
		N6	Other										2.000		**2.000**					
		N7	Water									1.000	6.000		**7.000**					
		N	**Total national natural resources**									**192.000**	**64.000**		**256.000**		**1.000**	**1.000**		**1.000**
	7. ROW origin		Non-cultivated biological assets																	
			Fish									4.000			**4.000**					
			Water										1.000		**1.000**		1.000	**1.000**		
			Total ROW natural resources									**4.000**	**1.000**		**5.000**		**1.000**	**1.000**		
Ecosystem Inputs	8. National environment	**E1,E2**	**National ecosystem inputs**									**15.000**	**81.000**	**22.000**	**118.000**	**10.000**	**13.000**	**23.000**		**2.000**
	9. ROW origin	**E1,E2**	**ROW ecosystem inputs**											**3.000**	**3.000**	**1.000**		**1.000**		
Residuals	10. National origin	R1	CO_2																	
		R2	N_2O																	
		R3	CH_4																	
		R4	NO_X																	
		R5	SO_2																	
		R6	NH_3																	
		R7	Other																	
		R8	P											0.020	**0.020**					
		R9	N											0.115	**0.115**					
		R10	Other											0.010	**0.010**					
		R11	Mining waste																	
		R12	Other solid waste									0.240	2.680	3.780	**6.700**				**25.810**	
			Total national									**0.240**	**2.680**	**3.925**	**6.845**				**25.810**	
	11. ROW origin	R1-R12	Cross-border residual flows from ROW																	
Total				132.000	288.000	219.000	20.000	4.000	15.000	23.000	701.000	285.240	485.680	59.925	**830.845**	19.000	46.000	**65.000**	**144.810**	**104.000**

Source: SEEAland data set.

Table 3.12. Full matrix presentation of the physical flows between the economy and the environment *(continued)*

Millions of tons

				Residuals															
				10. National destination													11. ROW destination	Material balance	**Total**
				R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	**Total**			
Economy	1. Products	P1	Animal and vegetable products																132.000
		P2	Stone, gravel and building materials																288.000
		P3	Energy																219.000
		P4	Metals, machinery etc.																20.000
		P5	Plastic and plastic products																4.000
		P6	Wood, paper etc.																15.000
		P7	Other product groups																23.000
			All products																**701.000**
	2. Industries	I1	Agriculture, fishing and mining	19.020	0.007	0.073	0.061	0.023	0.020	0.010	0.070	0.590	0.030	7.233	8.103	**35.240**			285.240
		I2	Manufacturing, electricity and construction	111.398	0.042	0.452	0.275	0.139	0.123	0.061	0.020	0.210	0.021	2.320	71.619	**186.680**			485.680
		I3	Services	29.930	0.012	0.125	0.151	0.030	0.038	0.015	0.004	0.098	0.006	0.000	22.929	**53.338**	4.587		59.925
		I	**Total industries**	**160.348**	**0.061**	**0.650**	**0.487**	**0.192**	**0.181**	**0.086**	**0.094**	**0.898**	**0.057**	**9.553**	**102.651**	**275.258**	**4.587**		**830.845**
	3. Consumption	C1	Own account transport	16.908	0.003	0.004	0.084	0.003	0.000	0.000					0.100	**17.102**	0.745	1.153	19.000
		C2	Other consumption	25.080	0.004	0.020	0.026	0.001	0.007	0.012	0.011	0.117	0.021		5.060	**30.359**		15.641	46.000
		C	**Total consumption**	**41.988**	**0.007**	**0.024**	**0.110**	**0.004**	**0.007**	**0.012**	**0.011**	**0.117**	**0.021**		**5.160**	**47.461**	**0.745**	**16.794**	**65.000**
	4. Capital	**CF**	**Capital formation**	**0.990**		**0.477**					**0.003**	**0.024**	**0.001**		**71.100**	**72.595**		**72.215**	**144.810**
	5. ROW (origin)	**R1-R12**	**Generated by non-residents**	**4.172**	**0.001**	**0.001**	**0.025**	**0.001**			**0.001**	**0.006**	**0.001**		**1.548**	**5.756**		**- 51.756**	**104.000**
Natural resources	6. National environment		Subsoil assets																
		N1	Oil															- 38.000	
		N2	Gas															- 27.000	
		N3	Other															- 173.000	
			Non-cultivated biological assets																
		N4	Wood etc.															- 9.000	
		N5	Fish															- 2.000	
		N6	Other															- 2.000	
		N7	Water															- 7.000	
		N	**Total national natural resources**															**- 258.000**	
	7. ROW origin		Non-cultivated biological assets																
			Fish															- 4.000	
			Water															- 2.000	
			Total ROW natural resources															**- 6.000**	
Ecosystem Inputs	8. National environment	**E1, E2**	**National ecosystem inputs**															**- 143.000**	
	9. ROW origin	**E1, E2**	**ROW ecosystem inputs**															**- 4.000**	
Residuals	10. National origin	R1	CO_2															207.498	207.498
		R2	N_2O															0.069	0.069
		R3	CH_4															1.152	1.152
		R4	NO_X														0.669	0.070	0.739
		R5	SO_2														0.196	0.088	0.284
		R6	NH_3														0.099	0.108	0.207
		R7	Other														0.002	0.098	0.100
		R8	P														0.010	0.093	0.123
		R9	N														0.543	0.710	1.368
		R10	Other														0.002	0.071	0.083
		R11	Mining waste															9.553	9.553
		R12	Other solid waste														2.398	153.207	188.115
			Total national														**3.919**	**372.717**	**409.291**
	11. ROW origin	R1-R12	Cross-border residual flows from ROW				0.117	0.087	0.019	0.002		0.323	0.003		7.656	**8.221**		**1.030**	**9.251**
Total				207.498	0.069	1.152	0.739	0.284	0.207	0.100		1.368	0.083	9.553	188.115	409.291	9.251	**0.000**	**2 264.197**

Table 3.13. Physical supply and use table

Physical supply table

Millions of tons

			Industries				Consumption			Capital	Rest of the world				National environment	
			Agriculture, fishing and mining	Manufacturing and electricity construction	Services	**Total industries**	Own account transport	Other consumption	**Total consumption**	**Capital formation, changes in inventories, waste storage**	Imports of products	Natural resources and ecosystem inputs supplied by non-residents in national territory	Residuals by non-residents in ROW	Cross-boundary inflows from ROW by environmental media		**Total material supply**
			I1	I2	I3	**I**	C1	C2	**C**	**CF**	M2	M1	M1	M3	E	
Products	P1	Animal and vegetable products	66.000	49.000	1.000	**116.000**					16.000					**132.000**
	P2	Stone, gravel and building materials	112.000	163.000		**275.000**					13.000					**288.000**
	P3	Energy	65.000	59.000		**124.000**					95.000					**219.000**
	P4	Metals, machinery etc.		10.000		**10.000**					10.000					**20.000**
	P5	Plastic and plastic products		2.000		**2.000**					2.000					**4.000**
	P6	Wood, paper etc.	7.000	7.000		**14.000**					1.000					**15.000**
	P7	Other commodities		9.000	1.000	**10.000**					13.000					**23.000**
		All products	**250.000**	**299.000**	**2.000**	**551.000**					**150.000**					**701.000**
Residuals		To national territory														
	R1	CO_2	19.020	111.398	29.930	**160.348**	16.908	25.080	**41.988**	**0.990**			4.172			**207.498**
	R2	N_2O	0.007	0.042	0.012	**0.061**	0.003	0.004	**0.007**				0.001			**0.069**
	R3	CH_4	0.073	0.452	0.125	**0.650**	0.004	0.020	**0.024**	**0.477**			0.001			**1.152**
	R4	NO_X	0.061	0.275	0.151	**0.487**	0.084	0.026	**0.110**				0.025	0.117		**0.739**
	R5	SO_2	0.023	0.139	0.030	**0.192**	0.003	0.001	**0.004**				0.001	0.087		**0.284**
	R6	NH_3	0.020	0.123	0.038	**0.181**		0.007	**0.007**					0.019		**0.207**
	R7	Other to air	0.010	0.061	0.015	**0.086**		0.012	**0.012**					0.002		**0.100**
	R8	P	0.070	0.020	0.004	**0.094**		0.011	**0.011**	**0.003**			0.001	0.014		**0.123**
	R9	N	0.590	0.210	0.098	**0.898**		0.117	**0.117**	**0.024**			0.006	0.323		**1.368**
	R10	Other to water	0.030	0.021	0.006	**0.057**		0.021	**0.021**	**0.001**			0.001	0.003		**0.083**
	R11	Mining waste	7.233	2.320		**9.553**										**9.553**
	R12	Other solid waste	8.103	71.619	22.929	**102.651**	0.100	5.060	**5.160**	**71.100**			1.548	7.656		**188.115**
		Total to national territory	35.240	186.680	53.338	**275.258**	17.102	30.359	**47.461**	**72.595**			5.756	8.221		**409.291**
		To ROW territory														
		To air														
	R1	CO_2			4.569	**4.569**	0.739		**0.739**							**5.308**
	R4	NO_X			0.010	**0.010**	0.004		**0.004**							**0.014**
	R5	SO_2			0.008	**0.008**	0.002		**0.002**							**0.010**
		Total to ROW territory			4.587	**4.587**	0.745		**0.745**							**5.332**
		Total residuals	**35.240**	**186.680**	**57.925**	**279.845**	**17.847**	**30.359**	**48.206**	**72.595**			**5.756**	**8.221**		**414.623**
Total material supply			285.240	485.680	59.925	**830.845**	17.847	30.359	**48.206**	**72.595**	**150.000**		**5.756**	**8.221**		**1 115.623**
							Net increase by consumption (consumer durables)			Net increase in capital	Net export of products	Net extraction by non-residents	Net residuals by residents in ROW	Net cross-boundary outflow of residuals by environmental media	Net accumulation of residuals in the national environment	**Net balance**
Net accumulation of all materials (use less supply)							1.153	15.641	16.794	72.215	-49.000	3.000	-0.424	-4.302	372.717	411.000

Source: SEEAland data set.

Table 3.13. Physical supply and use table *(continued)*

Physical use table

Millions of tons

			Industries				Consumption			Capital	Rest of the world				National environment	
			Agriculture, fishing and mining	Manufacturing and electricity construction	Services	**Total industries**	Own account transport	Other consumption	**Total consumption**	**Capital formation, changes in inventories, waste storage**	Exports	Resources and ecosystem inputs used by non-residents in national territory	Residuals by residents in ROW	Cross-boundary outflows to ROW by environmental media		**Total material use**
			I1	I2	I3	**I**	C1	C2	**C**	**CF**	X2	X1	X1	X3	E	
Products	P1	Animal and vegetable products	23.000	60.000	4.000	87.000		16.000	16.000	3.000	26.000					**132.000**
	P2	Stone, gravel and building materials	12.000	148.000	2.000	162.000		2.000	2.000	114.000	10.000					**288.000**
	P3	Energy	34.000	101.000	20.000	155.000	7.000	10.000	17.000		47.000					**219.000**
	P4	Metals, machinery etc.		11.000		11.000	1.000		1.000	1.000	7.000					**20.000**
	P5	Plastic and plastic products		2.000		2.000					2.000					**4.000**
	P6	Wood, paper etc.		7.000	4.000	11.000		1.000	1.000		3.000					**15.000**
	P7	Other commodities	5.000	8.000	1.000	14.000		2.000	2.000	1.000	6.000					**23.000**
		All products	**74.000**	**337.000**	**31.000**	**442.000**	**8.000**	**31.000**	**39.000**	**119.000**	**101.000**					**701.000**
Natural resources		National natural resources														
	N1	Oil	38.000			38.000										**38.000**
	N2	Gas	27.000			27.000										**27.000**
	N3	Other	118.000	55.000		173.000										**173.000**
	N4	Wood	7.000	1.000		8.000		1.000	1.000							**9.000**
	N5	Fish	1.000			1.000						1.000				**2.000**
	N6	Other		2.000		2.000										**2.000**
	N7	Water	1.000	6.000		7.000										**7.000**
		Total national natural resources	192.000	64.000		256.000		1.000	1.000			1.000				**258.000**
		ROW natural resources														
	N5	Fish	4.000			4.000										**4.000**
	N7	Water		1.000		1.000		1.000	1.000							**2.000**
		Total ROW natural resources	4.000	1.000		5.000		1.000	1.000							**6.000**
		Total natural resources	**196.000**	**65.000**		**261.000**		**2.000**	**2.000**			**1.000**				**264.000**
Ecosystem Inputs		National ecosystem inputs	15.000	81.000	22.000	118.000	10.000	13.000	23.000			2.000				**143.000**
		ROW ecosystem inputs			3.000	3.000	1.000		1.000							**4.000**
		Total ecosystem inputs	**15.000**	**81.000**	**25.000**	**121.000**	**11.000**	**13.000**	**24.000**			**2.000**				**147.000**
Residuals		From national territory														
	R1	CO_2													207.498	**207.498**
	R2	N_2O													0.069	**0.069**
	R3	CH_4													1.152	**1.152**
	R4	NO_X												0.669	0.070	**0.739**
	R5	SO_2												0.196	0.088	**0.284**
	R6	NH_3												0.099	0.108	**0.207**
	R7	Other from air												0.002	0.098	**0.100**
	R8	P			0.020	0.020								0.010	0.093	**0.123**
	R9	N			0.115	0.115								0.543	0.710	**1.368**
	R10	Other from water			0.010	0.010								0.002	0.071	**0.083**
	R11	Mining waste													9.553	**9.553**
	R12	Other solid waste	0.240	2.680	3.780	6.700				25.810				2.398	153.207	**188.115**
		Total from national territory	0.240	2.680	3.925	6.845				25.810				3.919	372.717	**409.291**
		From ROW territory														
	R1	CO_2											5.308			**5.308**
	R4	NO_X											0.014			**0.014**
	R5	SO_2											0.010			**0.010**
		Total from ROW territory											5.332			**5.332**
		Total	**0.240**	**2.680**	**3.925**	**6.845**				**25.810**			**5.332**	**3.919**	**372.717**	**414.623**
Total material use			285.240	485.680	59.925	830.845	19.000	46.000	65.000	144.810	101.000	3.000	5.332	3.919	372.717	**1 526.623**

Aggregate tables

3.148 It is possible to have an even more compressed matrix than that in Table 3.11, one showing only the flows between the economy and the environment. This was described schematically in Table 3.1 and is shown numerically in Table 3.14.

Table 3.14. Aggregate flows between the economy and the environment

Millions of tons

	National		Rest of the world (ROW)			
	Economy	Environment	Economy	Environment	Net material accumulation	Total
National economy		395 -33	101	6	89	558
National environment	398		3	4	-28	377
ROW economy	150	6				
ROW environment	10	8				
Total	558	377				

Source: SEEAland data set.

3.149 The first step is to derive columns 1 of Table 3.14 by consolidating the data found in columns 1-4 of Table 3.11 (note that the data presented in Table 3.14 have been rounded to the nearest whole number for simplicity of presentation). The entry for the national environment is derived by consolidating the data in rows 6 and 8 of Table 3.11. The entry for the rest of the world economy is simply the figure for product imports from row 5 of Table 3.11. The figure for the rest of the world environment is a consolidation of the data in rows 7 and 9 in Table 3.11.

3.150 The first row of Table 3.14 is derived by consolidating the data found in rows 1-4 of Table 3.11. The one exception is the entry for the national environment, which is a consolidation of the data in rows 1-4, column 10, of Table 3.11 less the data in columns 1-4, row 10. This is necessary in order to show the flows from the national economy to the national environment net of the residuals that are “used” through reabsorption into production and landfilling.

3.151 The remaining entries in Table 3.14 are derived as follows. The figure for the flow from the rest of the world economy to the national environment is taken from the intersection of row 5 and column 10 of Table 3.11. The figure for the flow from the rest of the world environment to the national environment is taken from the intersection of row 11 and column 10 of Table 3.11. The figure for the flow from the national environment to the rest of the world economy is a consolidation of the data in rows 6 and 7, column 5, of Table 3.11. Finally, the figure for the flow from national environment to the rest of the world environment is taken from the intersection of row 10 and column 11 of Table 3.11. As noted in the discussion of Table 3.1, the bottom right hand section of Table 3.14 is empty because flows between the rest of the world environment and the rest of the world economy are not recorded.

3.152 The data in the first row and column of Table 3.14 can also be structured as an account explaining the net material accumulation in the economic sphere. This is presented in Table 3.15.

Table 3.15. Physical flows and material balance for the economic sphere

Millions of tons

Origin		Destination	
Import of products	150	Export of products	101
Natural resource extraction		Gross output of residuals to national environment	395
From the national environment	257	Gross output of residuals to ROW environment	6
From the rest of the world environment	6	*less* recycling and landfill	-33
Ecosystems input			
From the national environment	141		
From the rest of the world environment	4		
		Net material accumulation in the economic sphere	**89**
Total material inputs	558	Total material outputs	558

Source: SEEAland data set.

3.153 A similar account, drawn from row and column 2 of Table 3.14, can be constructed to explain the net material accumulation in the environmental sphere, as shown in Table 3.16.

Table 3.16. Physical flows and material balance for the environmental sphere

Millions of tons

Origin		Destination	
Gross output of residuals to the national environment	395	Natural resource extraction	
less recycling and landfill	-33	To the national economy	257
Discharge from ROW economy	6	To the rest of the world economy	1
Cross-border residual flows from ROW environment	8	Ecosystems input	
		To the national economy	141
		To the rest of the world economy	2
		Cross-border residual flow to another country	4
		Net material accumulation in the environmental sphere	**-28**
Total material inputs	377	Total material outputs	377

Source: SEEAland data set.

3.154 The last aggregate table of interest (Table 3.17) has been produced to demonstrate in what form the net material accumulation in the economy takes place. This table shows how the total net material accumulation in the economy (89 million tons) is brought about by a net inflow of products of 49 million tons from the rest of the world, 28 million tons from the national environment and 12 million tons from the environment of the rest of the world. These figures can be derived from the last column of Table 3.11. The net flows from the environment are calculated as residuals generated less natural resource and ecosystem inputs. The material accumulation in the economy is accounted for as 72 million tons of capital and 17 million tons of consumer durables.

Table 3.17. Material accumulation in the economic sphere

Million of tons

Origin		Destination	
Balance of trade	49	Net increase in capital and other stocks	72
		Net increase in consumer durables	17
Net material absorption			
from the national environment	28		
from the rest of the world	12		
Total	89	Total	89

Source: SEEAland data set.

7. Input-output identities

3.155 Sections 2-6 above provide an overview of the different flows represented in the system of physical flow accounts and show how these can be brought together to give a measure of the net material accumulation in each of the several sectors of the economy and in the environment.

3.156 The entries for rows and columns 1 to 5 of Table 3.11 all relate to products, and separate accounts can be constructed for each type of economic activity (production, capital accumulation and consumption) as well as for transactions with the rest of the world. This is achieved in Table 3.18.

3.157 As noted before, for production there is a complete balance between inputs and outputs.

3.158 A separate capital account shows, on the input side, the amount in physical terms of gross fixed capital formation and net changes in inventories. A decline in the inventories of certain product groups may possibly result in negative entries on the input side of the capital account. The using up of capital will usually not produce a continuous flow of residuals over time, as residuals are recorded as being generated at the moment when the capital item is discarded. This is shown on the output side of the account as part of the generation of residuals.

3.159 The capital account displays another feature. The controlled storage of waste as landfill is also regarded as material accumulation taking place within the economic sphere. Therefore, the input side of the capital account shows the absorption of residuals that corresponds to the gross increase in waste stocks. Leakages from landfill sites appear on the output side of the account as a further source of residuals generated by capital.

3.160 For household consumption, the accounts do not create a division between current and capital flows. The input side shows consumption of households and the extraction of natural resources. The output side shows the residual disposal by households. The difference between inputs and outputs is made up by the net increase in transport equipment and other consumer durables.

3.161 With respect to the rest of the world, two separate balancing items are included. One represents the difference between exports and imports (the physical balance of trade). The data show that in the SEEAland economy, the mass of imports substantially exceeds exports so there is a net inflow of material into the economy from other economies. The second balancing item shows the net balance of residual transfers where, again, there is a net inflow into the national environment from the rest of the world.

Table 3.18. Input-output relationships for economic activities

Millions of tons

Inputs		Outputs	
Production			
Intermediate consumption	442	Output	551
Extraction of natural resources	261		
Ecosystem inputs	121		
Re-absorption of residuals	7	Generation of residuals	280
Total material inputs	831	Total material outputs	831
Capital formation			
Capital formation and changes in inventories	119	Generation of residuals	73
Waste to landfill sites (absorption of residuals)	26	Net material accumulation in the economy	72
Total material inputs	145	Total material outputs	145
Consumption			
Household consumption	39	Generation of residuals	48
Extraction of natural resources	2	Net material accumulation in the economy (consumer durables)	17
Ecosystem inputs	24		
Total material inputs	65	Total material outputs	65
Rest of the world			
Exports	101	Imports	150
		Net material accumulation of products in the rest of the world	-49
Total material inputs	101	Total material outputs	101
Residuals generated by residents in the rest of the world	5	Residuals generated by non-residents in the national economy	6
Ecosystem inputs to the rest of the world	3	Ecosystem inputs from the rest of the world	10
Cross-boundary flows to the rest of the world	4	Cross-boundary flows from the rest of the world	8
		Net accumulation of residuals in the rest of the world	-12
Total flows to the environment from the rest of the world economy	12	Total flows to the rest of the world environment from the economy	12

Source: SEEAland data set.

D. Physical flow accounts in practice

1. Introduction

3.162 In the present section, practical examples of physical flow accounts are given. They show how supply and use tables have been presented in practice and how related accounts have been constructed for supply or use of materials.

3.163 The first two examples demonstrate possible alternative presentations of the treatment of residuals. The first of these is an example investigating the flow of residuals and their use (or not) for recycling based on data for (Western) Germany for 1990. The second, also based on German data for 1990, concerns the question of ecosystem inputs and the consequences for recording the impact of generation of products and the recording of residuals.

3.164 The third example shows how the various stages in the product cycle of natural resources can be explained. It concerns the supply and use of timber and forest products in Finland. This example shows traditional supply and use tables for products and residuals even though the format of the tables is somewhat different from the general format presented above in section C.

3.165 The last two examples focus on economy-wide flow accounts and the various indicators that can be derived from them. The first is a brief description of material flow accounting (MFA) and the second of physical input-output tables (PIOT).

2. Residuals and recycling in physical flow accounts (Western Germany, 1990)

3.166 Residuals directly discharged into the environment cross the border between the economy and the environment; other residuals remain within the economy. Residuals for recycling are an input into the recycling industries. Residuals for treatment are mainly an input of wholesale trade into waste and scrap or environmental services. In addition, some other industries may treat their own residuals or those of other industries. Waste for landfills is that part of the waste that is stored in controlled landfills and is considered to be an accumulation of produced assets.

3.167 The numerical example shown in Table 3.19 is taken from German physical input-output table for 1990. It is a very inclusive table of materials used or otherwise affected by economic activity. Although products are measured at only 10 billion tons, the total of natural resources and ecosystem inputs is more than four times this weight and residuals more than five times. The main reason for this is the amount of water that is affected in one way or another by the economy.

3.168 The German accounts are characterized by very detailed information on the nature of residuals, which can be subdivided according to their four principal destinations:

(a) Residuals discharged into the environment;

(b) Residuals for recycling;

(c) Residuals for treatment;

(d) Residuals (waste) for landfill

Table 3.19. Material flow account for Western Germany, 1990

Millions of tons

	Production activities of branches				Consumption activities of households	Produced assets		Non-produced natural assets	Rest of the world	Total
	Recycling	External environmental protection services	Other branches	Total		Consumer durables, inventories, fixed assets, produced natural assets	Controlled landfills			
					Inputs (use)					
Raw materials	13	3 510	45 707	49 230	280					49 510
Raw materials used (including. air, minerals)	12	10	1 858	1 880	221					2 101
Raw materials not used			982	982						982
Water raised	1	3 500	42 868	46 369	59					46 428
Products	9	17	5 684	5 710	3 075	854			206	9 845
Residuals	104	4 427	3	4 535			117	49 046	2	53 700
Waste for recycling	104			104						104
Waste for treatment		31	3	34					2	36
Waste for landfill							117			117
Raw materials not used								982		982
Other material discharged								614		614
Waste water for treatment		4 396		4 396						4 396
Waste water discharged								44 847		44 847
Water evaporated								1 566		1 566
Oxygen								226		226
Carbon dioxide								778		778
Other air emissions								34		34
Total inputs	126	7 954	51 394	59 475	3 355	854	117	49 046	208	113 055
					Outputs (supply)					
Raw materials								49 510		49 510
Raw materials used (including air, minerals)								2 101		2 101
Raw materials not used								982		982
Water raised								46 428		46 428
Products	91	0	9 139	9 231		222			393	9 845
Residuals	35	7 954	42 255	50 244	3 355	100				53 700
Waste for recycling	0	6	77	83	4	17				104
Waste for treatment	1	4	18	23	4	8				36
Waste for landfill	1	2	84	87	11	20				117
Raw material, not used			982	982						982
Other material discharged	13	11	515	539	20	56				614
Waste water for treatment	4	0	1 756	1 760	2 636					4 396
Waste water discharged		7 895	36 952	44 847						44 847
Water vaporized	5	22	1 066	1 094	472					1 566
Oxygen			226	226						226
Carbon dioxide	11	12	560	583	195					778
Other air emissions	0	1	19	21	13					34
Total outputs	126	7 954	51 394	59 475	3 355	323		49 510	393	113 056

Source: Stahmer, Kuhn and Braun (1996)

3.169 An examination of the table shows that the inputs and outputs for production and consumption are equal but that there is a transfer of material from the environment (49,510 - 49,046 = 464 million tons) and the rest of the world (393 – 208 = 185 million tons) to the economy, specifically as an increase in consumer durables, fixed capital and inventories (854 – 323 = 531 million tons) and to controlled landfills (117 million tons).

3. Biological assets and ecosystems inputs

3.170 For the material flows connected with agricultural and forestry production, in practice the distinction between the economic and the environmental sphere is particularly difficult to make in statistical terms. According to the SNA production boundary, cultivated plants and cultivated animals are the results of production processes and have therefore to be regarded as products. An exception holds only for wild biota. They are considered to be raw materials extracted from the environment. However, unlike other purely technical processes of production, which are almost completely under human control, agricultural and forest production is mainly the result of biological metabolism, whereby the cultivated biological organisms interact more or less directly with the environmental sphere by extracting raw materials and by discharging residuals. The biological metabolism is supported by further production activities (other metabolism) like ploughing, harvesting and transport which are also connected with use of materials (such as energy).

3.171 The total metabolism and especially the biological metabolism in agriculture can conceptually be described in terms of the physical input-output table which is based on the identity of physical inputs and outputs for each industry. This concept allows a complete picture to be drawn of the material flows necessary for the metabolism of cultivated plants and animals. The inputs into biological metabolism are raw materials such as water or air (oxygen, carbon dioxide) and products such as animal feeds, seeds, fertilizers and pesticides. The metabolic outputs include the natural growth of plants, animals, animal products and residuals (evaporated water, liquid manure and so on). To arrive at the identity of material inputs and outputs, all physical flows of the metabolic processes have to be included. Ecosystem inputs are absorbed by biological assets, both cultivated and non-cultivated. The consequences are of significant importance in their own right for several reasons. One concerns the carbon-fixing role of plants and forests, which is independent of the distinction between cultivated and non-cultivated assets. Another concerns the role of residuals, particularly the eutrophication caused by intensive animal husbandry. The third reason is that there are practical issues concerned with data compilation for the physical accounts for produced assets when ecosystem inputs must be taken into account as well as products and residuals.

3.172 The statistical implementation of this concept is rather difficult. As a rule, except for the output and input of products, only rough estimates for the elements of biological metabolism are possible. For these estimates, physiologic information has to be combined with data on the production of cultivated plants and animals by categories. It is also rather difficult to arrive at an estimate of what part of the fertilizers, farm manure and pesticides is incorporated into cultivated plants and what part is dissipated directly into the environment, for example, as nitrate pollution of groundwater.

3.173 For practical purposes, especially if it is not the aim to construct a complete PIOT but only a material balance for the whole economy, a simplified version may be sufficient. To see how this can be done, it is useful to look at some illustrative figures for animal husbandry and plants and forests separately.

Animal husbandry

3.174 Even when the cultivation of animals falls clearly within the production boundary, the pattern of inputs may vary substantially. In some countries where cattle ranching is prevalent with low densities of animals per hectare, as in many developing countries, virtually all the fodder and water may be provided from natural ecosystems with comparatively few other inputs. In contrast, in much of Europe, most of the fodder and water will itself be classed as products, and other inputs, such as veterinary expenses, may be significant. In these circumstances, intensive animal husbandry is more like an industrial process than a purely natural one.

3.175 For all animals, however, whether cultivated or not, ecosystem inputs in the form of oxygen and water are essential to life. By volume, most of the oxygen is converted to carbon dioxide and a large proportion of the food and water input is converted to solid, liquid and gaseous residuals, for example, carbon dioxide and methane from the animals' digestive processes. The value of physical output is equal to the value of weight gain by the animals and this is usually a fairly small proportion by volume of the inputs. Table 3.20 gives an idea of the relative orders of magnitude involved. It is drawn from the same physical input-output table for Western Germany as the data in Table 3.19.

Table 3.20. Metabolism account for cultivated livestock

Millions of tons

Inputs (uses)		Output (supply)	
Ecosystem inputs	137.5	**Products**	32.3
Water from nature	115.7	Biomass increase	32.3
Oxygen	21.8		
Products	169.3	**Residuals**	274.5
Water	53.3	Water	7.8
Agricultural products	98.3	Excreta	241.3
Other products	17.7	Carbon dioxide	23.8
		Methane	1.6
Total inputs	306.8	**Total outputs**	306.8
Water	169.0	Water	7.8
Other inputs	137.8	Materials (excluding water)	299.0

Source: Stahmer, Kuhn and Braun (1996).

Plants and forests

3.176 Although plants and forests (hereinafter referred to, for convenience, as "plants") are grouped with animals as biological resources, their interaction with the environment is entirely different. Plants absorb mainly carbon dioxide and water and convert these into oxygen and an increase in weight (production, in the case of cultivated assets). The weight of oxygen released by plants is about two thirds the weight of carbon dioxide absorbed so the increase in weight of the plants is accounted for by this "fixing" of the carbon and the absorption of water. Although all the water absorbed is retained (most is lost through evapotranspiration), the net retention is still significant.

3.177 Other inputs into plant cultivation are relatively small by volume and mainly comprise fertilizers and pesticides. Not all of these are absorbed by the plants; some reach the soil or watercourses (dissipative losses).

3.178 Because of the difficulties of measuring the ecosystem inputs accurately, the following pragmatic approach is often followed. The increase in the biomass of plants is accurately measured and is taken, by convention, to be equal to the net value of ecosystem inputs (that is, water and carbon dioxide in, less oxygen and water vapour out). The value of other inputs is taken, also by convention, to be equal to the value of other residuals. This assumes that the take-up by plants of fertilizers is exactly offset by plant residues such as dead leaves. While obviously not strictly correct and not in strict accordance with the measurement of production using SNA conventions, this approach does rely on direct measurement and the statistical error introduced by it in practice is unlikely to be significant. Table 3.21 gives an example for plants and forests under detailed accounting and using the simplification suggested here. This simplification is incorporated in the example on material flow accounting discussed in subsection 5 below.

Table 3.21. Metabolism account for plants

Millions of tons

	Full biological metabolism			Pragmatic approach		
	Cultivated plants other than forests	Cultivated forests	Plants and forests	Cultivated plants other than forests	Cultivated forests	Plants and forests
	Inputs (uses)			Inputs (uses)		
Ecosystem inputs	385.3	47.5	432.8			
Water from nature	107.6	13.8	121.4			
Minerals	0.7	0.0	0.7			
Carbon dioxide	277.0	33.7	310.7			
Biomass increase				195.1	23.0	218.1
Products	11.2	0.1	11.3	11.2	0.1	11.3
Water	5.7	0.0	5.7	5.7	0.0	5.7
Agricultural products	1.3	0.0	1.3	1.3	0.0	1.3
Fertilizers, pesticides	4.2	0.1	4.3	4.2	0.1	4.3
Total inputs	396.5	47.6	444.1	206.3	23.1	229.4
Water	113.3	13.8	127.1	5.7	0.0	5.7
Other inputs	283.2	33.8	317.0	200.6	23.1	223.7
	Output (supply)			Output (supply)		
Products	195.1	23.0	218.1	195.1	23.0	218.1
Biomass increase	195.1	23.0	218.1	195.1	23.0	218.1
Other products	0.0	0.0	0.0	0.0	0.0	0.0
Residuals	201.4	24.6	226.0	11.2	0.1	11.3
Water vapour etc.	0.0	0.0	0.0	5.7	0.0	5.7
Oxygen	201.4	24.6	226.0	0.0	0.0	0.0
Agricultural products				1.3	0.0	1.3
Fertilizers, pesticides				4.2	0.1	4.3
Total outputs	396.5	47.6	444.1	206.3	23.1	229.4
Water	0.0	0.0	0.0	5.7	0.0	5.7
Materials (excluding water)	396.5	47.6	444.1	200.6	23.1	223.7

Source: Stahmer, Kuhn and Braun (1996).

3.179 In Germany, all animal husbandry is treated as production because of the intensive nature of the activity. In countries where intensive animal husbandry is not common, a pragmatic approach, similar to that shown above for plants and forests, may be appropriate. This is also the approach that is likely to be useful in measuring the take-up of ecosystem inputs and the generation of residuals by non-cultivated biological resources.

4. Accounts for timber and wood products

3.180 One application of the principles of accounting for physical flows of materials is to follow the progress of a natural resource through the successive stages of its absorption into various products. Table 3.22 and Table 3.23 give an example for timber and wood products based on Finnish data for 1995.

3.181 Table 3.22 is divided into two vertical sections and three horizontal ones with a final balancing row. The top left sub-matrix of the table shows the supply of three sorts of wood from fellings and from imports. Felled timber is either coniferous softwood or broad-leaved hardwood. The figures here are consistent with those referring to the volume of harvested timber in the asset accounts for standing timber in chapter VIII. Fuelwood from fellings is mainly small-size timber, which is felled and removed from the forest directly for combustion purposes. Some supply of each of these three sorts of timber goes to export and some goes to inventories (or is supplied from inventories). A balance can thus be made of the total supply available for domestic use. For fuelwood, the “other supply” row indicates logging residues from the forestry and logging industries that are collected for industrial and small-size combustion. Fuelwood is mainly burnt in households and in agriculture and also, though to a limited extent, in the energy sector.

3.182 The fourth and fifth columns relate to the production and use of wood residues as raw materials and fuel. Residues (chips, bark, sawdust and particles) originate in the processing of saw logs and pulp wood in the saw-milling, veneer and pulp industries. Most residues (chips) are used as raw materials in pulp production and in particle and fibre board production; and some in wood industries. Residues as fuel (bark, sawdust and particles) are burnt both in power plants mainly providing energy to forest industries and in power plants for general energy production included in the industrial sector of electricity, gas, steam and hot water supply (the "energy sector").

3.183 In Table 3.22, different units are used depending on in what is most appropriate for the product in question. The first three columns relate to felled timber measured in solid cubic metres. The right-hand columns in the sub-matrices are shown in cubic metres for sawn wood, veneers and particle and fibre boards, and metric tons for mechanical and chemical pulp, sulphate liquors, paper and paper board and recycled paper.

Table 3.22. Material flows of timber and forest products in Finland, 1995

	Products			Residues		Forest industries outputs					
	Saw logs	Pulp wood	Fuel wood	Fuel	Raw material	Sawn wood and veneers	Particle and fibre board	Mechanical and chemical pulp	Sulphate (black liquors)	Paper and board	Recycled paper
	Thousands of solid cubic metres							Thousands of metric tons			
Supply for domestic use											
Fellings as harvested timber	25 680	26 310	4 720								
Import	640	9 920		42	681	216	55	96		204	68
Outputs of forest industries				6 277	10 685	10 258	573	10 088	9 803	10 941	
Other supply			300								512
Export	- 858	- 175		- 1	- 163	-8 089	- 282	-1 302		-9 603	- 35
Inventories	77	-4 353	..	..	- 504	- 51	2			- 50	..
Total a	**25 539**	**31 702**	**5 020**	**6 318**	**10 699**	**2 334**	**348**	**8 882**	**9 803**	**1 492**	**545**
Forest industries											
Sawing, planing and veneer production											
Inputs	-23 770	- 790	- 17	-1 008		- 50	- 1				
Outputs				3 786	10 685	10 258					
Particle and fibre board production											
Inputs		- 20		- 282	-1 050	- 6				- 3	
Outputs				5			573				
Mechanical and chemical pulp production											
Inputs	-1 470	-31 120	- 12	-3 989	-9 210				-9 313		- 70
Outputs				2 486				10 088	9 803		
Paper and board production											
Inputs								-8 750		- 64	- 380
Outputs										10 941	
Total Inputs b	**-25 240**	**-31 930**	**- 29**	**-5 279**	**-10 260**	**- 56**	**- 1**	**-8 750**	**-9 313**	**- 67**	**- 450**
Other industries (Inputs to)											
Wood industries	- 406	- 54		- 80	- 31	- 618	- 100				
Paper goods, printing and publishing								- 38		-1 370	- 75
Energy sector			- 97	- 904							
Building and construction	- 101	- 23				-1 706	- 241				
Others and households use	- 15		-4 867		- 47	- 53	- 6	- 94	- 5	- 73	
Total Inputs c	**- 522**	**- 77**	**-4 964**	**- 984**	**- 78**	**-2 377**	**- 347**	**- 132**	**- 5**	**-1 443**	**- 75**
Losses, statistical error (a+b+c)	- 223	- 305	27	55	361	- 99	0	0	485	- 18	20

Source: Statistics Finland.

3.184 The middle section of the table relates to forest industries. One line shows in negative figures the inputs a series of forest industries ("inputs"); sawing, planning and veneer production, particle and fibre board production. The subsequent line shows in positive figures the production of residues and forest industry products ("outputs"). The total production, as the sum of all positive entries in this second part of the table, also appears in the row "Output of forest industries" in the top right sub-matrix. The total use of the products within the forest industries is shown as the sum of all the negative entries at the bottom of the middle section of the table. For example, the industry for sawing, planning and veneer production uses 23,770 thousand solid cubic metres of saw logs, 790 thousand solid cubic metres of pulp wood, 17 thousand solid cubic meters of fuelwood and 50 thousand cubic metres of sawn wood and veneers and particle and fibre board. This is turned into 10,258 thousand cubic metres of sawn wood and veneers and 14,471 (10,685+3,786) thousand solid cubic metres of residues. Of these residues, 1,008 thousand solid cubic metres is used as fuel in sawing, planning and veneer industries.

3.185 The third sub-matrix shows the use of felled timber and forest industry products, not accounted for in earlier parts of the table, as inputs to non-forest industries and other uses. The heading "Wood industries" includes the manufacture of prefabricated buildings, carpentry and furniture. "Others and household use" includes agriculture, households, the rest of manufacturing industry and other industries. All the entries in this part of the table are negative since they all relate to uses.

3.186 Once the lower sub-matrices are completed, the upper part of the table can be completed. Total production of forest products is shown in the right part, and exports and changes in inventories are also recorded. The balance for this part of the table shows the supply available domestically for the year in question for each sort of timber and forest products. In principle, this supply must be used either by forest industries or by other industries. In practice, an arithmetical residual is calculated and ascribed to losses and statistical error.

A picture of the role of forestry in the economy

3.187 . Supply and use balances can be presented by individual timber assortments and products, and/or aggregated timber and product categories as in Table 3.22. The table shows that most saw logs are transformed into sawn wood and veneers. Some saw logs are used in the wood industries, in the construction industries and even in the pulp industries. The majority of sawn wood and veneer is exported but a significant proportion goes into the construction industry and the wood industry. Particle and fibre boards are made mainly from residues, and pulp is made from both pulp wood and residues. Pulp output goes mainly into paper and paperboard production as does an amount of recycled paper. Some pulp is exported. Paper and board in turn go into paper goods production and printing and publishing, but again the vast majority is exported. Sulphate liquors from processes of chemical pulp production (the wood content of these liquors is 70 per cent) are burnt for energy production in chemical pulp mills.

Mass balances

3.188 Wood material balances for inputs and outputs in each branch of forest industries, and also at the level of the national economy, can be calculated by converting timber and products into a common unit. Conversion factors from volume and weight of timber and products to weight of dry wood take into account the water contents of timber and products, as well as such items as glues, chemicals, coating materials and other components in forest industry products. A summary table of Finnish supply and use mass balance for wood material is presented in Table 3.23. The mass balance of wood material can be expanded to a wider material balance by using the "natural" weights of timber and products, adding the inputs of materials other than wood, and by presenting the fuel use as air emissions and other wastes from combustion.

3.189 Tables presented on material flow and balances draw on information from specialist trade associations and research institutes as well as information collected in a statistical office. They are useful in understanding the implications for industrial activity of the existence of significant forest reserves and harvest, especially when linked to employment and regional data. They also form a vital role in providing the basic input-output tables in monetary terms.

Table 3.23. Mass balance of timber and forest products in Finland, 1995

Millions of dry-matter tons of wood

Inputs		**Outputs**	
Saw logs and pulp wood	-24.4	Exported raw wood	0.5
Forest industry	-24.2	Forest industry products	14.0
Domestic wood	-19.4	Sawn goods and veneers	4.5
Imported wood	-4.8	Particle and fibre boards	0.3
Other use	-0.2	Exported residues	0.1
Fuelwood	-2.1	Exported pulp	1.2
Imported residues and pulp	-0.3	Paper and board	8.0
Recycled paper	-0.4	Fuel	11.2
		Residues	2.6
		Black liquor	6.5
		Fuel wood	2.1
		Other goods	0.2
		Wood waste	1.2
Total	-27.3	**Total**	27.2
		Losses, error	-0.1

Source: Statistics Finland.

5. Economy-wide Material flow accounting (MFA)

Introduction

3.190 The purpose of economy-wide material flow accounting (MFA) is to provide an aggregate overview, in tons, of annual material inputs and outputs of an economy including inputs from the national environment and outputs to the environment and the physical amounts of imports and exports. Economy-wide MFA and balances constitute the basis for derivation of a variety of material flow-based indicators (Eurostat, 2001a, p. 15).

3.191 As mentioned in section A, there is little that conceptually distinguishes MFA from physical supply and use tables. However, some general differences can nevertheless be outlined, as follows:

- In general, MFA focuses on the overall flows into and out of an economy. The product flows within the national economy are not described;
- MFA requires that all materials be accounted for. Supply and use tables are often set up for a subset of materials;
- In MFA, flows of materials are often aggregated in order to produce indicators for total material flows. Supply and use tables are often more detailed;
- MFA operates at two levels; one for direct flows and one for indirect flows. The direct flows are those that cross either the border between the national environment and the national economy (national resources) or the border between the rest of world economy and the national economy (imported products). These flows are a subset of flows described in physical supply and use tables. The indirect flows described by MFA occur either within the environment (for

example, mining overburden) or within the rest of the world (in particular resource extraction in other countries). These flows are not depicted by physical supply and use tables.

- Due to the more aggregated focus in MFA, much of the detail on the domestic origin and destination (breakdown on industries and households) can be avoided. Thus, for the direct flows, MFA is less demanding with respect to data and labour needed for compiling the accounts. On the other hand, MFA is very demanding when it comes to the indirect flows.

3.192 The physical flow accounts can be presented at different levels of aggregation. Probably the most condensed form of presentation is the so-called economy-wide material flow accounts as presented in Table 3.24. Accounts of this type have been published (Adriaanse and others, 1997) for Germany, Japan, the Netherlands and the United States of America. A highly simplified version of the economy-wide material flow account has already been represented by the overview scheme of the economic sphere presented in section B. In economy-wide material flow accounts, the material inputs and total material outputs are balanced by the net material accumulation in the economic sphere. In the construction of these accounts, the transfers within the national economic sphere such as (intermediate) consumption can basically be ignored. Only the underlying mass flows of imported and exported products have to be taken into consideration.

3.193 A major aim of economy-wide material flow accounts is the estimation of the total material requirement of a national economy. This is the sum of the total material input in the economy. Besides the direct material inputs presented in Table 3.24, material flows within the environment are also taken into consideration. These flows consist of:

Ancillary flows: material that must be removed from the natural environment, along with the desired natural recourse, to obtain the natural resource.

Excavated or disturbed flows: material that is moved or disturbed to obtain the natural resource.

These flows are sometimes described as hidden flows, indirect flows or unused extraction.

3.194 It is important to further narrow down the boundaries of the physical flow accounts as discussed in the first section of this chapter in order the know to what extent supplementary estimations are required for the coverage of hidden flows. For example, the ancillary mass flow of ore residuals may already have been taken into account by the production or import of ore and subsequently in the residual output of steel manufacturers. Secondly, from a conceptual point of view, the excavated material with respect to the construction of infrastructure such as highways or buildings contributes to the total material accumulation in the economic sphere as an increase in capital stock. Therefore, this material input and accumulation should be recorded as such in the tables.

3.195 In a publication of the World Resources Institute (Adriaanse and others, 1997) the estimation of hidden flows connected to imported products is also taken into consideration. The total material requirements related to products not only consist of these hidden flows but may also include other products, such as energy inputs and capital that will never be physically embodied in the final imported product. Input-output analysis can be a very helpful tool in systematically estimating these indirect material requirements of final products.

3.196 The level of "dematerialization" of the economy can be shown by a comparison of the changes in the volumes of total material requirements with those of gross domestic product. When the balancing item of net material accumulation in the economic sphere is relatively small, most of the total material input is released back into the environment. With respect to residual outputs, it is very important to know some of the elementary characteristics in order to understand the environmental consequences of these residual outputs. Hazardous materials such as heavy metals are often represented by tiny mass flows that are easily hidden in the margins of error of the accounts. However, the account presented in

Table 3.24 can also be constructed for particular material flows such as energy (denominated in joules), nutrients, heavy metals etc. Also, for these partial material flows, the same underlying definition equation applies:

> products imported + natural resource extraction = products exported + net residual output + material accumulation in the economic sphere

3.197 Table 3.24 is a typical presentation of a material flows account that is consistent with Table 3.15 and, indeed, constitutes essentially just a different way of presenting the same information. Compared with the above-mentioned MFA accounts for Germany, Japan, the Netherlands and the United States and the guidelines published by Eurostat, Table 3.24 deviates with respect to the treatment of cultivated biological products. In the table shown here, ecosystem inputs used for the growth of these products are recorded. In "traditional" MFA accounting, the total quantity of harvest of plants are recorded instead of the ecosystem inputs; but since, in practice, this difference is of minor importance and, in order to highlight the connection with the supply and use tables, the MFA accounting conventions have been interpreted loosely here.

Table 3.24. Economy-wide material flow account

Millions of tons

	Inputs	Outputs
Economic sphere		
Products		
Imports	150 000	
Exports		101 000
Environmental sphere		
Natural resources		
Subsoil deposits	238 000	
Non-cultivated biological assets	16 000	
Water	12 000	
Air (O_2, N_2)	142 000	
Residuals		
To air		210 956
To water	145	1 226
Solid waste	32 510	188 464
Total material accumulation in the economic sphere		89 009
Total inputs/outputs	590 655	590 655

Source: SEEAland data set.

Indicators based on material flows analysis

3.198 MFA-based indicators, comprising of input indicators, output indicators and consumption indicators, have been proposed for the purpose of providing an overview on the headline issues of resource use, waste disposal and emissions to air and water.

Input indicators

3.199 ***Direct material input*** (DMI) measures the input of materials used in the economy, that is, all materials that are of economic value and are used in production and consumption activities; DMI equals domestic (used) extraction plus imports. Materials that are extracted by economic activities but that do not normally serve as input for production or consumption activities (mining overburden etc.) have been termed unused extractions. They are not used for further processing and are usually without economic value. DMI plus unused domestic extraction constitute total (domestic) material input.

3.200 The ***total material requirement*** (TMR) includes, in addition to DMI, the upstream hidden material flows that are associated with imports and predominantly burden the environment in other countries. It measures the total "material base" of an economy, that is, the total primary resource requirements of the production activities. Adding these upstream flows converts imports into their "primary resource extraction equivalent".

Output indicators

3.201 ***Domestic processed output*** (DPO) represents the total mass of materials that have been used in the national economy before flowing into the environment. These flows occur at the processing, manufacturing, use, and final disposal stages of the economic production-consumption chain. Exported materials are excluded because their wastes occur in other countries. Included in DPO are emissions to air from commercial energy combustion and other industrial processes, industrial and household wastes deposited in landfills, material loads in wastewater, materials dispersed into the environment as a result of product use (dissipative flows), and emissions from incineration plants. Material flows recycled in industry are not included in DPO.

3.202 ***Total domestic output*** (TDO): the sum of DPO and disposal of unused domestic extraction. This indicator represents the total quantity of material outputs to the environment released on the national territory by economic activity.

3.203 ***Direct material output*** (DMO): the sum of DPO and exports. This parameter represents the total quantity of direct material outputs leaving the economy after use either towards the environment or towards the rest of the world.

3.204 ***Total material output*** (TMO): the sum of TDO plus exports. It therefore measures the total quantity of material that leaves the economy.

Consumption indicators

3.205 ***Domestic material consumption*** (DMC) measures the total quantity of material directly used in an economy, excluding hidden flows. DMC equals DMI minus exports.

3.206 ***Total material consumption*** (TMC) measures the total primary material requirement associated with domestic consumption activities. TMC equals TMR minus exports and their hidden flows.

3.207 ***Net additions to stock*** (NAS) measures the physical growth rate of an economy. New materials are added to the economy's stock each year (gross additions) in buildings and other infrastructure, and materials are incorporated into new durable goods such as cars, industrial machinery and household appliances, while old materials are removed from stock as buildings are demolished and durable goods disposed of.

3.208 ***Physical trade balance*** (PTB) measures the physical trade surplus or deficit of an economy. PTB equals imports minus exports. Physical trade balances may also be defined including hidden flows associated with imports and exports (for example, on the basis of TMC accounts).

6. The physical input-output table (PIOT)

Construction of the PIOT

3.209 Based on a set of physical supply and use tables for all materials (or a subset of these), it is possible to construct a physical input-output table that shows the physical flows (or the subset of materials) from the environment or rest of the world to the economy, within the economy, and from the economy to the rest of the world or the environment in a condensed way.

3.210 Supply and use tables are asymmetric in the sense that they show industries and other economic entities in one dimension and products or materials in the other. They are industry-by-products tables. In contrast, input-output tables are symmetric: they are either industry-by-industry or product-by-product tables.

3.211 In order to convert the asymmetric physical supply and use tables into symmetric physical input-output tables, some assumptions and techniques are needed. These are in fact the same assumptions and techniques that are used when monetary supply and use tables are converted into monetary input-output tables. Monetary input-output tables are described briefly in chapter IV and in greater detail in the 1993 SNA (chap. XV) and in the *Handbook of Input-Output Table Compilation and Analysis* (United Nations, 1999a).

3.212 Table 3.25 is an example of an industry-by-industry physical input-output table corresponding to the physical supply and use tables presented earlier in section C.

Table 3.25. Physical input-output table

Millions of tons

	Industries				Capital	Households	ROW exports	Residuals	Accumulation	Total
	I1	I2	I3	I	CF	C	X	R		
I1 Agriculture, fishing and mining	26.258	120.799	10.581	157.638	45.833	14.290	32.239	35.240		285.240
I2 Manufacturing, electricity and construction	26.446	146.144	10.263	182.853	66.526	13.401	36.221	186.680		485.680
I3 Services	0.392	0.802	0.074	1.268	0.066	0.208	0.458	57.925		59.925
I Total industries	53.096	267.746	20.917	341.758	112.425	27.899	68.918	279.845		830.845
CF Capital								72.595	72.215	144.810
C Households								48.206	16.794	65.000
M ROW imports	20.904	69.254	10.083	100.242	6.575	11.101	32.082	5.756	-51.756	104.000
N Natural resources	196.000	65.000		261.000		2.000	1.000			525.000
E Ecosystem inputs	15.000	81.000	25.000	121.000		24.000	2.000			268.000
Absorption of residuals	0.240	2.680	3.925	6.845	25.810					39.500
Total	285.240	485.680	59.925	830.845	144.810	65.000	104.000	406.402	37.253	

Source: SEEAland data set.

3.213 The columns in the PIOT show the input into the corresponding category and the rows show output from the category. It is seen that agriculture has a total input of 285,240 kilotons, of which 26,446 kilotons are products received from manufacturing, electricity and construction, 196,000 kilotons are natural resources, 15,000 kilotons are ecosystem inputs and 240 kilotons are residuals received for reabsorption or recirculation. The total input has been converted to an amount of output equal to input. Thus, the row sum for agriculture is also 285,240 kilotons. The cells in the row show that this amount includes 120,799 kilotons received by manufacturing, electricity and construction and 35,240 kilotons of residuals.

3.214 In the PIOT, inputs (column totals) equal outputs (row totals) for each of the industries, for capital, for households and rest of the world. No balancing items for the environment as such are introduced in the table shown.

3.215 If Table 3.25 is compared with Table 3.12, it is seen that entries in the rows in the supply and use table showing the use of products have been so converted in the input-output table as to show the source as coming from a particular national industry or the rest of the world as imports. The total inputs for each category within each column remain unaltered, however. It can also be seen that the totals and balancing items for industries, capital, households and the ROW are equal in each table. For the rest of the world, the balancing item in the PIOT (-51,756 kilotons) is the sum of the net material balance for products (trade balance) and residuals coming from non-residents on the national territory less ecosystem inputs to the rest of the world. The table focuses on flows coming from economic activity on the territory. Thus, the transboundary flows of residuals by environmental media and the flows related to resident units abroad have not been introduced in Table 3.25; but by introducing more columns and rows, this can be done in the same way as in Table 3.12.

Examples of the PIOT

3.216 Compiling a physical input-output table in practice is an extensive task. Although it does not involve any tasks that have not already been covered in principle, in practice many more data entries need to be considered. Generally, it will be possible to construct a physical table only when detailed monetary supply and use tables already exist because for some entries the physical quantities will have to be determined by dividing the monetary figures by appropriate prices. In any case, both tables should exist side by side to ensure that analytical lessons from the two are consistent with the pattern of prices and quantities to be observed in the economy. Descriptions of the compilation of physical input-output tables are available in Stahmer, Kuhn and Braun (19996) for Germany and Gravgaard Pedersen (1999) for Denmark, among others.

3.217 Besides compiling a complete table in physical terms for all materials, in some cases, it is possible to compile supply and use tables or physical input-output tables for some of the materials or chemical substances that are relevant to environmental policy. Two examples are given here, one for packaging materials and one for the nitrogen content of goods.

Packaging

3.218 The example for packaging materials shows how a subgroup of products of particular policy interest can be derived from a full, detailed supply and use table for all products. Alternatively, particular tables for the specific subgroup can be constructed directly on the basis of production statistics and foreign trade statistics.

3.219 Table 3.26 shows the main supply and use aggregates related to aggregates of 30 different types of packaging, including sheets, foils, bags, sacks, carboys, bottles, drums, pallets, boxes, tubes, barrels, stoppers and caps made of plastic, wood, paper, cardboard, glass or metal.

3.220 The supply consists of imports and materials needed for the production of empty packaging. When materials needed for the production of packaging are included as supply instead of packaging materials as such, a double counting of packaging used as input for the production of other packaging materials is avoided. On the use side, exports and use by industries and households are the main components even though some gross fixed capital formation (for example, pallets) and changes in inventories are recorded as well. Of course, more detail can be introduced, for example, by distinguishing among types of materials used for the packaging (plastic, wood, paper etc.) or, if a physical input-output table based on the detailed supply and use table is constructed, analysis can be made of the flows of packaging within the economy.

Table 3.26. Supply and use of packaging in Denmark, 1990

Kilotons

Supply		Use	
Imports of empty packaging	191	Exports	251
Materials for the production of		Gross fixed capital formation	14
empty packaging	883	Changes in inventories	-18
		Use in industries and households	827
Total	**1 074**	**Total**	**1 074**

Source: Gravgaard Pedersen (1999).

Nitrogen

3.221 The example for nitrogen illustrates the more complicated cases in which materials or chemical substances are not commodities as such and therefore not explicitly included in the supply and use tables for products. However, in some cases such as that of nitrogen, it is possible to calculate the content in the various commodities supplied to and used in the economy. The starting point is a detailed supply and use table for all commodities that include nitrogen (food, feeding stuff, fertilizers, other chemical products, wood, textiles, plastics etc.). For each accounting entry in the physical supply and use table for the products, the nitrogen content expressed as the proportionate weight of nitrogen per unit of product is multiplied by the weight of the product. In this way, a supply and use table for the nitrogen flows embedded in products is obtained. Table 3.27 shows aggregated results of such a calculation based on supply and use information for approximately 800 products and matching nitrogen percentages.

Table 3.27. Supply and use of nitrogen embedded in products in Denmark, 1990

Kilotons

Origin/supply		Destination/use	
Imports	784	Exports	296
Danish resources	98	Gross fixed capital formation	2
		Changes in stocks	47
		Losses etc.	536
Total	**882**	**Total**	**882**

Source: Gravgaard Pedersen (1999).

3.222 Nitrogen flows to the economy consisted of 784 kilotons of nitrogen in imported commodities plus 98 kilotons included in biomass extracted from the domestic environment. Thus, the total supply of nitrogen was 882 kilotons.

3.223 This quantity is broken down on the use side into 296 kilotons in exports, 47 kilotons in inventory changes, 2 kilotons accumulated in connection with gross capital formation (agricultural breeding stock etc.) and 536 kilotons as a residual, which include losses to the Danish environment.

3.224 Based on the detailed physical supply and use table for nitrogen flows, a physical input-output table for the flows can be constructed in order to analyse the flows in more detail. Table 3.28 shows an aggregated version including three main groups of industries. This table includes inter-industry flows of nitrogen embedded in products, flows from industries to final uses (private consumption, fixed capital formation, inventory changes and exports), imports and flows from environment with reference to the biological fixation of nitrogen during (produced) biomass growth. A column for the nitrogen losses from industries and households is introduced in the table. This loss corresponds to the difference between the total input for each of the industries and the output for intermediate consumption and final uses. The nitrogen content supplied to private consumption from domestic industries and imports is, as a whole, also recorded in the physical input-output table's residual part on the basis of an assumption that nitrogen is finally returned to the environment in conjunction with waste and sewage.

Table 3.28. Aggregated physical input-output table for nitrogen flows in Denmark, 1990

Kilotons

	Intermediate consumption				Final demand					Losses to the environment etc.	Total
	1. Agriculture etc.	2. Manufacturing etc.	3. Services	Total	Private consumption	Capital formation	Changes in stocks	Exports	Total		
1. Agriculture, horticulture, fishing, mining etc.	52	156	1	209	6	1	7	87	101	446	**755**
2. Manufacturing, construction etc.	187	90	10	288	32	1	55	195	283	24	**595**
3. Services	–	–	–	–	8	–	–	–	8	7	**15**
Domestic industries total	239	246	11	496	46	1	62	282	391	477	**1 365**
Imports	419	349	4	771	12	0	- 14	14	12	-	**784**
National resources: biological fixation of nitrogen etc.	98	–	–	98							**98**
Nitrogen from private consumption										59	**59**
Total	**755**	**595**	**15**	**1 365**	**59**	**2**	**47**	**296**	**404**	**536**	**2 305**

Source: Gravgaard Pedersen (1999).

Note: A dash (–) indicates that the amount is nil; "0" indicates a positive amount less than 0.5.

Chapter IV. Hybrid flow accounts

A. Overview

1. Objectives

4.1 Chapter III introduced a set of physical flow accounts using classifications and a structure familiar to national accountants. In the present chapter, the analytical potential of juxtaposing these data with the corresponding monetary flow accounts is explored. In addition, the extra robustness in both sets of data that comes from considering them simultaneously is discussed. One strength of this approach is that the integration of physical and monetary accounts in this way does not impact any of the SNA accounting conventions. Those who wish to examine the implications of environmental phenomena within the context of the national accounts as currently defined and understood therefore find this a particularly attractive presentation. The possibilities of integration in which SNA accounting conventions are modified to yield additional macro-aggregates that incorporate information on environmental flows are discussed in chapters VIII and X.

4.2 This chapter should be considered in conjunction with chapter III. Much of the discussion therein, including many general accounting rules and definitions, although also relevant to this chapter, is not repeated here.

4.3 Throughout this chapter and in those that follow, reference is made to various national accounts tables as presented in the 1993 SNA. Indeed, it is the bringing together of environmental accounts and economic accounts that is the motivation of this entire Handbook. The 1993 SNA flexibility with respect to augmenting the system via satellite accounts allows the SEEA to be part of the wider set of national accounting formulations consistent with the 1993 SNA. It is not the intention of this Handbook to try to reproduce all the arguments underlying the rationale for the particular format of the economic accounts or to explain all the strict accounting conventions therein. A very brief overview of some of the important concepts of the SNA has been given in chapter II. Beyond that, it is assumed that those who are interested in this level of detail either are already well informed on the subject or will seek explanations in material dedicated to the economic accounts alone.

4.4 The term "hybrid flow accounts" is used to denote a single matrix presentation containing both national accounts in monetary terms and physical flow accounts showing the absorption of natural resources and ecosystem inputs and the generation of residuals. The acronym NAMEA has come into widespread use for these types of tables. It stands for the National Accounting Matrix including Environmental Accounts, which originated with the work developed throughout the 1990s by Statistics Netherlands. However, the notion of confronting monetary and physical data also lay at the core of the 1993 SEEA and the use of the term NAMEA should be seen as convenient shorthand for the development of the 1993 SEEA rather than as reflecting an alternative to it. Indeed, the basic principles of hybrid accounting structures as discussed in this chapter were actually developed in the late 1960s by Leontief (1970) and others (see, for example, Cumberland (1966); Daly (1968); Isard (1969); Ayres and Kneese (1969); and Victor (1972)). These researchers introduced the analysis of the "physical economy" by way of input-output modelling. They represented residual emissions as a by-product of regular production activities and showed how this could be incorporated in the conventional input-output framework. The underlying data system of their models comprised physical data, described in connection with monetary information on the economic structure. These data systems could be regarded as forerunners of the hybrid account.

4.5 Different forms of hybrid accounts exist. This chapter concentrates on two of them: first, hybrid supply and use tables; and then, hybrid input-output tables. A more extensive hybrid account that includes all the distributive and redistributive monetary accounts of the SNA is discussed in chapter VI following the discussion of other monetary flows in chapter V. A hybrid account records physical flows in a manner compatible with economic transactions as presented in the national accounts. This linkage guarantees a consistent comparison of environmental burdens with economic benefits, or environmental benefits with economic costs. This linkage can be examined not only at the national level but also at disaggregated levels, for example, in relation to regions of the economy, or specific industries, or for the purpose of examining the relations leading from the absorption of a particular natural resource or to the emissions of a particular residual. Because it combines physical data which may be of more immediate comprehensibility to scientists, with monetary data familiar to economists, it has the potential to form a bridge between these two schools of concern about the environment. An important point to note is that it is quite legitimate to include only a limited set of natural resources, ecosystem inputs and residual outputs, depending on the most urgent environmental concerns to be taken into consideration. It is certainly not necessary to complete an exhaustive natural resource input table, or a residual output table. This is also true for the overall accounting framework that is to be used. National accounting matrices, supply and use tables and input-output tables can each be used as an appropriate framework, depending on the intended analysis and the availability of data.

4.6 A hybrid account thus represents an analytical framework showing which parts of the economy are most relevant to specific indicators and how changes in the economic structure influence the evolution of indicators over time. Further, because the accounts provide consistent environmental and economic indicators, the possible trade-offs in environmental terms between alternative environmental and economic strategies can be analysed. At finer levels of disaggregation, the hybrid accounting framework provides the scientific community with access to a structured database for further research into the role of these indicators in monitoring the overall environmental-economic performance of national economies. In this way, hybrid accounts build a bridge between (aggregate) policy assessment and (underlying) policy research.

2. Products and industries

4.7 The physical flow accounts presented in chapter III are centred around the distinction between natural resources, ecosystem inputs, products and residuals: natural resources and ecosystem inputs enter the economy; residuals eventually leave it. Economic activity itself is concerned with the production and consumption of goods and services (products). All natural resources and ecosystem inputs absorbed by the economy are converted into products by one means or another. All physical products eventually return to the environment as residuals. It is the process in between, when products circulate within the economy, that is of interest for economic accounting, since this is the point in the cycle when monetary values can be associated with the flows.

Supply and use tables

4.8 There are three basic economic activities recorded in the national accounts: production, consumption and accumulation. Accumulation may relate to physical products as capital formation or to intangible non-financial assets. For the present, it is the physical products that concern us and although some products remain within the economy for a period of time, maybe for a very long period as in the case of buildings, even these eventually return to the environment. Thus, we may focus on the processes of production and consumption within the context of accepting that the same process that applies to consumption will in the long run apply to physical accumulation also.

4.9 Confronting data on production and consumption is part of the process of matching supply and use of products. The important distinction between these two pairs of concepts is that production is undertaken by enterprises that we classify by industry but what is supplied and used (consumed) is expressed in terms of products. If there were always a simple one-to-one match between products and industries, statistical life would be simpler, with one classification being applicable to both. Some conventions can be adopted to approximate this as closely as possible. For example, we may say that there is an industry producing hydroelectricity, one producing nuclear electricity and several producing electricity by means of fossil fuel combustion, but in that case we designate each of these forms of electricity as separate products instead of treating all electricity as a single product.

4.10 Some products are available only in conjunction with other products, such as cotton and cotton seed, and some are available only as by-products, for example, molasses, which emerges from cane sugar refining. Some that have quite different purposes and therefore look quite different in a product classification are made by such similar technological processes that it is not practical to refine the industrial classification to the same extent as a product classification. As a case in point, the manufacturer of vehicle chassis may not know (or care) whether they are to be used for railway rolling stock or road vehicles even though rolling stock and road vehicles are made by different industries.

4.11 The data with which to compile a supply table comes from producers (that is, enterprises grouped by industry[12]). The value of production relates to all products made as do the sum of all products used for intermediate consumption and the components of value added. The data for a use table reflect information from producers and households on the products consumed. Imports and exports also are classified by products and not by the industry of production. Both supply and use tables show a cross-classification of industry by product. While the product totals and industry totals of the two matrices are identical pair-wise, two tables are necessary to reconcile supply and use when different classifications are used for each.

Input-output tables

4.12 A pair of supply and use tables is closest to the basic data available and is the starting point for any subsequent analysis of the interaction between products and producers. However, in order to look at the consequences of changing patterns of consumption for industrial output or import substitution, to take only two examples, it is necessary to be able to relate consumption and production directly. Input-output tables are the means of doing this. An input-output table takes a pair of supply and use tables and eliminates either the industry or product dimension to produce a single table showing both supply and demand according to a single classification. An input-output table is thus either a product-by-product table or an industry-by-industry table. Lengthy expositions and extensive algebra can be invoked to explain the transformation from supply and use tables to input-output table. More on this, together with a brief explanation of the transformation process involved, is given in section C.

3. Elaborating and using hybrid flow accounts

4.13 The elaboration and use of purely physical flow accounts were covered in chapter III with emphasis on environmental analysis. The remainder of this chapter discusses the two forms of hybrid

[12] Strictly speaking, Enterprises are a group of establishments and often are not homogeneous with respect to products. In the national accounts, data are needed for smaller units that are more homogeneous in terms of products.

tables mentioned above, supply and use tables and input-output tables. Discussion of the more complete form of a hybrid account where all income flows are also included is provided in chapter VI.

4.14 Section B is concerned with hybrid supply and use tables. Much experience in this area has been built around air emissions accounts, which are described at some length. It is important to recognize that this emphasis reflects experience to date and should not be interpreted as setting a limit to the applicability of supply and use tables. One part of the section describes the process of establishing a robust energy account, in physical terms, though making use of monetary information in the course of its derivation. The other part is devoted, inter alia, to some of the applications for deriving indicators combining both physical and monetary aspects of the use of environmental materials.

4.15 Section C describes input-output tables, concentrating not on the mechanics of producing an input-output table but on the various applications for which an input-output table is the appropriate tool. As in the case of the supply and use tables, the examples given are illustrative only and not meant to indicate that the tables are useful only for studying energy use and emissions accounts.

4. Scope and limitations of hybrid flow accounts

Work in progress

4.16 The full potential of hybrid accounts has not yet been exploited. Much of the experience to date has centred on developing air emission accounts on a supply and use basis. The Statistical Office of the European Communities (Eurostat) has sponsored work in all European Union (EU) countries so that the international applicability can be tested, and some cross-country results are now available (Eurostat, 2001d). Work is also progressing on accounts for water and waste (see, for example, Nordic Council of Ministers (2000)).

4.17 Those countries, such as the Netherlands and Denmark, that were the first to exploit the supply and use tables of the hybrid accounts, are, so far, the countries with the most experience in applying the input-output version of these tables. However, it will not be long before similar results are available for other countries developing the supply and use tables.

Time dimension

4.18 Accounts in matrix formats convey a great deal of material very succinctly, but each matrix refers only to a single time period. Especially for environmental concerns, the interest is in knowing whether and how fast behaviour is responding to environmental issues, through either the use of more advanced and more environmentally benign technologies or more cautious behaviour based on public perceptions about possible future damages and a desire to abide by precautionary principles. A hybrid account can be used to simulate alternative scenarios with different technological assumptions, but only when the compilation of such tables has become routine and a time series of tables exists, will it be possible to undertake an ex post investigation of the impacts of changing behaviour.

Quantity and volumes

4.19 A hybrid account, whether supply and use or input-output based, in effect has two overlapping matrices for products, one in monetary terms and one in physical terms. By implication, therefore, vectors and perhaps even matrices of prices are also available.

4.20 The national accounts pay attention to the means of distribution as much as to the means of production. Since it is virtually impossible to buy a pure good, this means national accounts prices are almost always composite indices which reflect not only the cost of production of the good but also the cost of getting it to market. In fact, two sets of prices are available within the national accounts tables. The first of these, referred to as "purchasers' prices", represent the total cost to the purchaser including any taxes on products payable at the point of sale, most importantly, valued-added tax (VAT). An alternative set of prices, called basic prices, are frequently used. These exclude taxes such as VAT and more nearly represent the value initially retained by the producer. They also exclude the "margin" charged by specialist wholesale and retail distributors to get the products to the marketplace and any transport costs that are billed separately to the purchaser. This means that the effects of most, but not all, taxes and most distribution costs are removed from basic prices. When there is a change in the level of taxes charged at the point of delivery or in the mechanism of retail and wholesale distribution, the movements in purchasers' prices and basic prices will differ, reflecting this structural change.

4.21 Increasingly, countries are beginning to implement monetary supply and use tables and input-output tables in both current and constant price forms. The ratio of current to constant prices also gives rise to an implicit price index. These implicit prices may be expressed at either purchasers' or basic prices. However, another important difference arises concerning units. Physical accounts are expressed in physical units, often tons, while national account volume figures are expressed in the numeraire of the base year (referred to by national accountants as "constant price currency units"). This distinction is easy to remember when the natural units are cited but less so if quantities or volumes are expressed in index number form and more particularly in the case of price indices.

4.22 In national accounting terms, a main objective of expressing amounts at constant prices is to measure economic growth, for which change in quality is as important as change in quantity. National accounts volumes and national accounts prices are thus always quality-adjusted. With the same deliberateness, physical quantities and prices are not quality-adjusted. In the case where there has been no quality change, the prices will coincide, but those wishing to derive physical quantities by dividing current price figures by prices must enquire whether these are or are not quality-adjusted and should not simply assume that there has been no change in quality.

4.23 When new technologies are adopted, it is important for the national accountant to decide whether the product produced with the new technology is simply a more expensive version of the previous product or a higher-quality version. For example, is a car with a catalytic converter simply a more expensive car or a package comprising the car plus some environmental services? Attention is drawn to this point because as increasing use is made of market instruments to invoke environmentally preferable behaviour, the consequences for SNA prices and SEEA prices may become more important, and analysis based on the inappropriate set of prices may be increasingly misleading. This issue is discussed further in section C of chapter V.

4.24 It is important to note and remember at various points in the following expositions that the prices derived from hybrid accounts are simply prices per physical quantity. They are thus not necessarily the same as the prices used in economic accounting when adjustments to prices to allow for changing qualities of products are incorporated. Where it is important to draw attention to this fact, the term "SEEA price" is used for the unadjusted price. Similarly, the term "volume" is used only in the context of quality-adjusted volumes and the term quantity is used when the physical measure is not adjusted for quality differences.

B. Hybrid supply and use tables

1. Introduction

4.25 The objective of a hybrid account is to bring together physical and monetary data in comparable terms. Since supply and use tables can be represented in both monetary and physical units, a choice must be made regarding which parts to show in monetary terms and which parts to show in physical units. In principle, the analyst has a degree of freedom in making this choice.

4.26 A logical starting point is to extend the national accounts by those pieces of information that are not captured in that system, that is to say, by the resource inputs and residual outputs. These do not appear in the SNA because there are no direct costs linked to their use or generation. The inclusion of physical flow accounts may be used to illustrate the importance and relative magnitude of these environmental interactions.

4.27 This choice preserves a strict boundary between the economic sphere and the environmental sphere, the former represented by accounts in monetary terms, the latter denominated in the most relevant physical units. In this presentation, the SNA is neither extended nor changed in respect of any of the basic principles concerning the transactions to be recorded, the manner of recording them or the prices applying to them. At the same time, the analytical power of the system is extended by juxtaposing information that can be directly related to the economic processes that consume the environmental inputs and generate the residuals. Production and consumption activities are described in terms not only of their transactions but also of their environmental requirements. In this respect, the economic as well as the environmental performance of the economy and the units in it can be evaluated together. This information is especially relevant in formulating policy strategies that are concerned with decoupling economic growth and environmental degradation.

2. The SEEAland hybrid supply and use tables

4.28 Table 4.1 comprises a supply and a use table in monetary units that corresponds exactly to the physical tables in Table 3.13. Both the similarities and the differences in format between monetary and physical tables are clear from a comparison of the two tables. The monetary tables concern products only, with no entries for natural resources, ecosystem inputs or residuals either used or generated.

4.29 The most significant difference is that two totals are shown for supply in monetary terms. The first of these shows the value retained by the producer, that is, production valued at basic prices. This is usually more than sufficient to cover all the costs the producer must bear, including some taxes on production such as taxes levied on the labour force or on the premises where production takes place. However, this value is usually lower than what the user pays because two factors intervene in bringing products to market. One of these is the margin levied by, typically, wholesalers and retailers, to get goods from the producers' factories to the marketplace where customers may have access to them. The other is the amount of tax levied by government at the point of sale. Increasingly, this tax often takes the form of some sort of VAT. The two totals are also affected by the fact that the first relates to production in the national economy only, whereas the second relates to all products available in the national market and thus includes imports. In this, the monetary tables resemble the physical ones, where total supply includes imports also. In monetary terms, though, both margins and taxes may apply to imports as well as to national production. Thus, in the upper part of Table 4.1, two totals are shown, one for production at basic prices and one for supply at market prices.

Table 4.1. Monetary supply and use tables

Total supply of products — Billion currency units

	Agriculture, fishing and mining	Manufacturing, electricity and construction	Services	Total domestic production at basic prices	Imports	Trade margins	Taxes less subsidies on products	Total supply at market prices
P1 Animal and vegetable products	39.4	45.0	0.0	84.4	11.2	9.4	0.6	105.6
P2 Stone, gravel and building materials	18.0	26.6	0.0	44.6	5.2	7.8	2.4	60.0
P3 Energy	132.9	125.1	0.0	258.0	82.9	17.5	13.9	372.3
P4 Metals, machinery etc.	0.0	67.2	0.0	67.2	70.0	6.0	1.9	145.0
P5 Plastic and plastic products	0.0	2.0	0.0	2.0	2.8	0.6	0.3	5.6
P6 Wood, paper etc.	2.2	16.8	0.0	19.0	1.9	2.1	0.9	24.0
P7 Other product groups	36.9	407.4	367.0	811.3	189.0	- 43.5	50.0	1 006.9
All products	229.4	690.0	367.0	1 286.4	363.0	0.0	70.0	1 719.4

Total use of products

	Intermediate consumption	Final consumption			Capital formation	Exports	Total use at market prices
P1 Animal and vegetable products	72.0	0.0	12.8	12.8	0.0	20.8	105.6
P2 Stone, gravel and building materials	54.5	0.0	1.0	1.0	0.0	4.5	60.0
P3 Energy	210.4	11.9	12.2	24.1	0.0	137.8	372.3
P4 Metals, machinery etc.	32.0	1.5	0.0	1.5	66.5	45.0	145.0
P5 Plastic and plastic products	4.2	0.0	0.6	0.6	0.0	0.8	5.6
P6 Wood, paper etc.	16.1	0.0	2.0	2.0	0.0	6.0	24.0
P7 Other product groups	274.8	0.5	463.9	464.4	79.5	188.2	1 006.9
All products	664.0	13.9	492.5	506.4	146.0	403.0	1 719.4

Source: SEEAland data set.

4.30 Another prominent difference between disaggregated monetary and physical tables concerns entries for services: they are very large in monetary terms and very small in physical terms. In terms of outputs of products, the cells for services in physical terms may often be shown as zero, although small entries may occur when the service concerned is delivered through a physical medium (as occurs, for example, with software and music disks, and in the case of catering establishments). On the other hand, virtually all service producers consume physical goods, if only office supplies, and generate residuals.

4.31 The classifications of products and industries in the monetary supply and use tables are the same as in the physical ones, depending on CPC and ISIC in both cases. Classifications of government and household consumption are also compatible, both systems drawing on COFOG and COICOP. In practice, and dealing with much bigger matrices, it is possible that there would be more detail shown in some areas and less detail in others. However, what is important is that exactly the same classification system is used so that complete consistency can be achieved by suitable aggregation.

4.32 Because there is a match between the monetary and physical amounts of products supplied, it is possible to calculate implicit prices for each commodity. These prices may be based on either the basic price valuation or the market price valuation of the monetary data. At this point, the discussion above on the difference between the implicit prices coming from such a comparison and the prices used in national accounts should be borne firmly in mind. Nevertheless, comparing these implicit prices with other price information available is one important way to control the quality of the data. Similarly, if the quantity figures have been derived by dividing the monetary figures by price indices, there must be a check that the resulting quantities make sense when compared across products.

4.33 The use table shows the same quantity of products in both physical and monetary terms as in the supply table. The fact that supply and use must be balanced in two dimensions is also a valuable part of the quality control process of compiling the data.

4.34 As explained in chapter III, the information in the supply and use tables can be merged into a single table. The use table stays in the format as above; the supply table is transposed and superimposed on the use table. Examples of the result of merging physical supply and use tables are shown in Tables 3.11 and 3.12.

4.35 Just as it is possible to combine supply and use tables in physical terms, so it is possible to do so for the monetary tables. This is a much smaller table since there are no rows or columns for natural resources, ecosystem inputs or residuals. Instead of a column to show the balancing item in physical terms, the material accumulation in the economy, there is a balancing row, value added, which could be viewed as a sort of “monetary accumulation” in the industries, that is, it represents the excess of revenue from selling products over the costs of the products needed to manufacture them. This table is shown as Table 4.2.

Table 4.2. Monetary supply and use table

Billions of currency units

			Economy																	Total
			Products								Industries				Consumption			Capital	Exports	
			P1	P2	P3	P4	P5	P6	P7	**P**	I1	I2	I3	**I**	C1	C2	**C**	**CF**	**X2**	
Products	P1	Animal and vegetable products									0.7	68.0	3.2	72.0		12.8	12.8	0.0	20.8	105.6
	P2	Stone, gravel and building materials									3.5	50.0	1.0	54.5		1.0	1.0		4.5	60.0
	P3	Energy									47.0	133.4	30.0	210.4	11.9	12.2	24.1	0.0	137.8	372.3
	P4	Metals, machinery etc.										32.0		32.0	1.5		1.5	66.5	45.0	145.0
	P5	Plastic and plastic products										4.2		4.2		0.6	0.6		0.8	5.6
	P6	Wood, paper etc.										10.1	6.0	16.1		2.0	2.0	0.0	6.0	24.0
	P7	Other product groups									26.6	213.4	34.8	274.8	0.5	463.9	464.4	79.5	188.2	1 006.9
		All products									77.8	511.2	75.0	664.0	13.9	492.5	506.4	146.0	403.0	1 719.4
		Trade margins	9.4	7.8	17.5	6.0	0.6	2.1	- 43.5											
		Product taxes	0.6	2.4	13.9	1.9	0.3	0.9	50.0	70.0								1.0		
Industries	I1	Agriculture, fishing and mining	39.4	18.0	132.9			2.2	36.9	229.4										
	I2	Manufacturing, electricity and construction	45.0	26.6	125.1	67.2	2.0	16.8	407.4	690.0										
	I3	Services							367.0	367.0										
	I	**Total industries**	84.4	44.6	258.0	67.2	2.0	19.0	811.3	1 286.4										
ROW	**M2**	**Imports of products**	11.2	5.2	82.9	70.0	2.8	1.9	189.0	363.0										
		Value added									151.6	178.8	292.0	622.4						
Total			105.6	60.0	372.3	145.0	5.6	24.0	1 006.9	1 719.4	229.4	690.0	367.0	1 286.4						

Source: SEEAland data set.

4.36 This table also shows the overall balancing item for the economy. There are three ways of calculating it (we mention two) – as the total for production by the national economy (1,286.4) less the total for all products used by industry (664.0), leaving 622.4 which is also total value added; and as the sum of consumption (506.4), capital (146.0) and exports (403.0) less imports (363.0) and taxes on products (70.0). Because GDP is usually measured in market prices, the value of taxes on products is usually added to the value of production and value added, rather than deducted in the third identity to give a figure for GDP of 692.4.

4.37 It would be possible to put Tables 3.13 and Table 4.1 next to each other to arrive at a hybrid supply and use account showing both physical and monetary data according to the same classifications in the same table. A more usual form, and the one most often used in the SEEA, is to use a format similar to that of Table 4.2. If Table 4.2 is compared with Table 3.12, it can be seen that the rows and columns of Table 4.2 correspond to the first two sets of rows and columns in Table 3.12. In addition, Table 3.12 contains the columns for residuals generated and the natural resources, ecosystem inputs and residuals that are used by industry. The normal hybrid supply and use table consists of exactly the same entries as those in Table 4.2 augmented by these “extra” rows and columns from Table 3.12, still expressed in physical terms. The result is shown in Table 4.3.

4.38 Figure 4.1 gives a schematic representation of the hybrid supply and use table. It includes a provision for the addition of ancillary information that may be useful, such as employment or energy use. In Table 4.3, the monetary blocks are shown in italics to distinguish them from the physical blocks, while in Figure 4.1, the monetary cells are shaded. Note that the material balance column shown at the end of Table 4.3 does not include entries for capital formation, consumption and imports. This is because all the physical data on product flows necessary to calculate these balances are not provided in the table. As a result, the material balance column does not sum to zero as would be the case if the balances for capital formation, consumption and imports were included. In Figure 4.1, there are no separate rows and columns to show whether natural resources and ecosystem inputs originate in the national or rest of the world environment or whether residuals are expelled nationally or internationally. Instead, these flows are indicated in the row for the rest of the world as origin and column for the rest of the world as destination. That is sufficient in a schematic matrix such as this where the exact origin and destination of the flows are of lesser importance. In practice, it is usual to show at least some of the distinction in detail. In Table 4.3, there are separate rows for the origin of each of natural resources, ecosystem inputs and residuals and a separate column for the destination of residuals. In this way, Table 4.3 can be compared exactly with Table 3.13. Provision of natural resources and ecosystem inputs to the national economy from the rest of the world environment and residuals destined for the rest of the world environment are shown in, respectively, the column containing exports of products and the row showing imported products. In this way, this row and column pair encapsulates the impact of the national economy on both the rest of the world economy and environment and vice versa.

Figure 4.1. Schematic diagram of a hybrid supply and use table

	Products	Industries	Consumption	Capital	Exports	Residuals
Products		Products used by industry (intermediate consumption)	Products consumed by households	Products converted to capital	Products exported	
Industries	Products made by industry					Residuals generated by industry
Consumption						Residuals generated by households
Capital						Residuals generated by capital
Imports	Products imported					Residuals imported
Margins	Trade and transport margins					
Taxes less subsidies on products	Taxes less subsidies on products					
Value added		*Value added by industry*				
Monetary totals	*Total products supplied*	*Total industry inputs*	*Total household consumption*	*Total capital Supplied*	*Total exports*	
Natural resources		Natural resources used by industry	Natural resources consumed by households		Natural resources exported	
Ecosystems inputs		Ecosystem inputs used by industry	Ecosystem inputs consumed by households		Ecosystem inputs exported	
Residuals		Residuals reabsorbed by industry		Residuals going to landfill	Residuals exported	
Other information		Employment Energy use	Energy use			

Table 4.3. Numerical example of a hybrid supply and use table

Monetary items (in italics) in billions of currency units; physical items in millions of tons

				Economy																
				1. Products								2. Industries				3. Consumption			4. Capital	5. Exports
				P1	P2	P3	P4	P5	P6	P7	**P**	I1	I2	I3	**I**	C1	C2	**C**	**CF**	**X2**
Economy	*1. Products*	*P1*	*Animal and vegetable products*									*0.7*	*68.0*	*3.2*	***72.0***		*12.8*	***12.8***	*0.0*	*20.8*
		P2	*Stone, gravel and building materials*									*3.5*	*50.0*	*1.0*	***54.5***		*1.0*	***1.0***		*4.5*
		P3	*Energy*									*47.0*	*133.4*	*30.0*	***210.4***	*11.9*	*12.2*	***24.1***	*0.0*	*137.8*
		P4	*Metals, machinery etc.*										*32.0*		***32.0***	*1.5*		***1.5***	*66.5*	*45.0*
		P5	*Plastic and plastic products*										*4.2*		***4.2***		*0.6*	***0.6***		*0.8*
		P6	*Wood, paper etc.*										*10.1*	*6.0*	***16.1***		*2.0*	***2.0***	*0.0*	*6.0*
		P7	*Other product groups*									*26.6*	*213.4*	*34.8*	***274.8***	*0.5*	*463.9*	***464.4***	*79.5*	*188.2*
			All products									***77.8***	***511.2***	***75.0***	***664.0***	***13.9***	***492.5***	***506.4***	***146.0***	***403.0***
			Trade margins	*9.4*	*7.8*	*17.5*	*6.0*	*0.6*	*2.1*	*- 43.5*										
			Product taxes	*0.6*	*2.4*	*13.9*	*1.9*	*0.3*	*0.9*	*50.0*	***70.0***								*1.0*	
	2. Industries	*I1*	*Agriculture, fishing and mining*	*39.4*	*18.0*	*132.9*			*2.2*	*36.9*	***229.4***									
		I2	*Manufacturing, electricity and construction*	*45.0*	*26.6*	*125.1*	*67.2*	*2.0*	*16.8*	*407.4*	***690.0***									
		I3	*Services*							*367.0*	***367.0***									
		I	***Total industries***	***84.4***	***44.6***	***258.0***	***67.2***	***2.0***	***19.0***	***811.3***	***1 286.4***									
	3. Consumption	*C1*	*Own account transport*																	
		C2	*Other consumption*																	
		C	***Total consumption***																	
	4. Capital	***CF***	***Capital formation***																	
	5. ROW (origin)	***M2***	***Imports of products***	*11.2*	*5.2*	*82.9*	*70.0*	*2.8*	*1.9*	*189.0*	***363.0***									
			Value added									*151.6*	*178.8*	*291.9*	***622.4***					
Natural resources	6. National environment		Subsoil assets																	
		N1	Oil									38.000			**38.000**					
		N2	Gas									27.000			**27.000**					
		N3	Other									118.000	55.000		**173.000**					
			Non-cultivated biological assets																	
		N4	Wood etc.									7.000	1.000		**8.000**		1.000	1.000		
		N5	Fish									1.000			**1.000**					1.000
		N6	Other										2.000		**2.000**					
		N7	Water									1.000	6.000		**7.000**					
		N	**Total national natural resources**									**192.000**	**64.000**		**256.000**		**1.000**	**1.000**		**1.000**
	7. ROW origin		Non-cultivated biological assets																	
			Fish									4.000			**4.000**					
			Water										1.000		**1.000**		1.000	1.000		
			Total ROW natural resources									**4.000**	**1.000**		**5.000**		**1.000**	**1.000**		
Ecosystem Inputs	8. National environment	**E1,E2**	**National ecosystem inputs**									15.000	81.000	22.000	**118.000**	10.000	13.000	23.000		2.000
	9. ROW origin	**E1,E2**	**ROW ecosystem inputs**											3.000	**3.000**	1.000		1.000		
Residuals	10. National origin	R1	CO_2																	
		R2	N_2O																	
		R3	CH_4																	
		R4	NO_X																	
		R5	SO_2																	
		R6	NH_3																	
		R7	Other																	
		R8	P											0.020	**0.020**					
		R9	N											0.115	**0.115**					
		R10	Other											0.010	**0.010**					
		R11	Mining																	
		R12	Other solid waste									0.240	2.680	3.780	**6.700**				25.810	
			Total national									**0.240**	**2.680**	**3.925**	**6.845**				**25.810**	
	11. ROW origin	R1-R12	Cross-border residual flows from ROW																	

Source: SEEAland data set.

Table 4.3. Numerical example of a hybrid supply and use table *(continued)*

Monetary items (in italics) in billions of currency units; physical items in millions of tons

				Residuals													
				10. National destination													11. ROW destination
				R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	**Total**	
Economy	1. Products	P1	Animal and vegetable products														
		P2	Stone, gravel and building materials														
		P3	Energy														
		P4	Metals, machinery etc.														
		P5	Plastic and plastic products														
		P6	Wood, paper etc.														
		P7	Other product groups														
			All products														
	2. Industries	I1	Agriculture, fishing and mining	19.020	0.007	0.073	0.061	0.023	0.020	0.010	0.070	0.590	0.030	7.233	8.103	**35.240**	
		I2	Manufacturing, electricity and construction	111.398	0.042	0.452	0.275	0.139	0.123	0.061	0.020	0.210	0.021	2.320	71.619	**186.680**	
		I3	Services	29.930	0.012	0.125	0.151	0.030	0.038	0.015	0.004	0.098	0.006		22.929	**53.338**	4.587
		I	**Total industries**	**160.348**	**0.061**	**0.650**	**0.487**	**0.192**	**0.181**	**0.086**	**0.094**	**0.898**	**0.057**	**9.553**	**102.651**	**275.258**	**4.587**
	4. Consumption	C1	Own account transport	16.908	0.003	0.004	0.084	0.003							0.100	**17.102**	0.745
		C2	Other consumption	25.080	0.004	0.020	0.026	0.001	0.007	0.012	0.011	0.117	0.021		5.060	**30.359**	
		C	**Total consumption**	**41.988**	**0.007**	**0.024**	**0.110**	**0.004**	**0.007**	**0.012**	**0.011**	**0.117**	**0.021**		**5.160**	**47.461**	**0.745**
	3. Capital	**CF**	**Capital formation**	0.990		0.477					0.003	0.024	0.001		71.100	**72.595**	
	5. ROW (origin)	R1-R12	Generated by non-residents	4.172	0.001	0.001	0.025	0.001			0.001	0.006	0.001		1.548	**5.756**	
Natural resources	6. National environment		Subsoil assets														
		N1	Oil														
		N2	Gas														
		N3	Other														
			Non-cultivated biological assets														
		N4	Wood etc.														
		N5	Fish														
		N6	Other														
		N7	Water														
		N	**Total national natural resources**														
	7. ROW origin		Non-cultivated biological assets														
			Fish														
			Water														
			Total ROW natural resources														
Ecosystem Inputs	8. National environment	**E1,E2**	**National ecosystem inputs**														
	9. ROW origin	**E1,E2**	**ROW ecosystem inputs**														
Residuals	10. National origin	R1	CO_2														
		R2	N_2O														
		R3	CH_4														
		R4	NO_X														0.669
		R5	SO_2														0.196
		R6	NH_3														0.099
		R7	Other														0.002
		R8	P														0.010
		R9	N														0.543
		R10	Other														0.002
		R11	Mining														
		R12	Other solid waste														2.398
			Total national														**3.919**
	11. ROW origin	R1-R12	Cross-border residual flows from ROW				0.117	0.087	0.019	0.002	0.014	0.323	0.003		7.656	**8.221**	

3. Emission accounts

4.39 As mentioned above, much of the practical experience to date on compiling hybrid supply and use tables concerns examining the consequences of the combustion of fossil fuels in terms of air emissions. The reasons for this interest are obvious; in terms of implementing Agenda 21 (United Nations, 1993a, resolution 1, annex II) it is the impact of carbon dioxide on global warming that has excited the most concern and controversy. It is therefore useful to explain in some detail how such air emissions accounts can be compiled and then used. It should be remembered, though, that this is meant to be only an example of how hybrid accounts can be used, not an exhaustive description of their use.

4.40 Energy accounts are of considerable interest in their own right, especially for countries heavily involved in oil mining and processing. At the same time, every economy in the world depends heavily on the availability of oil and other energy sources. The use of energy is critical to the economic process because almost all economic activity is connected either directly or indirectly with the consumption of energy. Energy accounts provide information on the levels of direct energy consumption of industries with respect to their production processes and of private households. The accounts can also provide information on changes in the energy requirements of particular industries in relation to their output. This shows the macrolevel impacts of new technologies and of eco-efficiency measures and behavioural changes. They are also an indispensable prerequisite for reliable estimates of air emissions related to energy consumption.

4.41 Combustion processes take place in many production and consumption activities, such as heating of houses and buildings, production of electricity, various industrial processes and transportation. The output of emissions resulting from combustion processes is primarily determined by (a) the type of fuel used and (b) the combustion process. The measurement of these emissions can come either from direct observations or from estimation. For example, many countries have environmental protection agencies that monitor emissions at sources for regulatory reasons. Also, the emissions from motor vehicles are usually analysed in detail.

4.42 Combustion-related emissions may be estimated by combining the amount of fuel used, as estimated in energy accounts, with emission factors relating to the type of fuel and given residual. One of the main uses to which material and energy balances can be put is the compilation of emissions accounts. While large point sources can contribute significant proportions of a given residual and may be measured directly, the estimation of combustion emissions from other sources can often be carried out satisfactorily only on the basis of energy balances.

4.43 The Intergovernmental Panel on Climate Change (IPCC) and the European harmonized system of air emissions (CORINAIR) provide reference data formulated in terms of emission output per unit of product. Although IPCC or CORINAIR inventories can be used as a starting point in the compilation of physical flow accounts for residual outputs, the harmonization of classifications is an important point of concern. Often these kinds of emission inventories are based on technical reports on industrial installations and plants. These functional or process-oriented classifications have to be brought in line with ISIC in order to make emissions data comparable with national accounts data. Also, emissions inventories usually relate to emissions on the national territory without regard to the resident status of the emitter. By contrast, the national accounts are defined on the basis of the resident principle which means that supplementary estimates are often required to adjust data from emission inventories to national accounts definitions. This point is taken up in detail below.

4.44 The complexity of emission estimation varies considerably between different residuals. For example, the emission of carbon dioxide (CO_2) for energy use is influenced to only a small extent by the type of combustion process. This means that information on fuel consumption and fuel-specific emission factors is sufficient to make a first rough estimation of CO_2 emissions. For sulphur dioxide (SO_2), this also applies, although knowledge of the sulphur content of fuel is obviously also important. Other emissions, such as those of nitrogen oxides (NO_X), can be reasonably estimated only on the basis of the technical characteristics of the combustion process. Usually, this means that the estimation of NO_X is more complex and the estimates are less reliable than for CO_2 and SO_2.

4. Energy balances and carbon dioxide emissions for Denmark

4.45 The present section gives an overview of the process of compiling CO_2 emissions. It is based on experience in Denmark, with some additional generalizations added. It begins by describing in some detail the compilation of energy balances in physical terms.

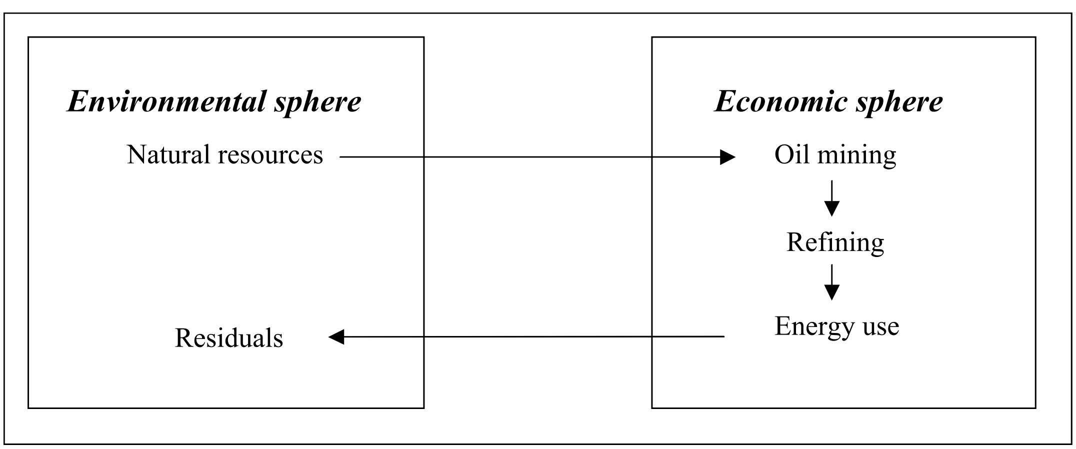
Energy balances: statistical sources and compilation methods

4.46 Energy and air emission accounts usually embrace all four types of physical flows: natural resource extraction (coal, crude oil and natural gas), ecosystem inputs (oxygen for combustion), products (energy products such as motive fuels and other fuel types) and residuals generated by the use of fossil fuels (emissions to air and other residuals such as ashes). Figure 4.2 summarizes the scope of the energy accounts.

4.47 The interest here is mainly on specific accounting techniques. Basic data on both energy supply and demand as well as on air emissions are taken as given and issues related to basic data gathering are discussed only briefly.

4.48 Physical energy accounts should be constructed in extended supply and use tables. Usually, the energy supply and use accounts will include both the monetary and the physical dimension in, say, tons or in their calorific equivalents. Supply of products is defined as domestic production plus import of the various energy commodities, while total product use is defined as the intermediate use by industries (classified by ISIC), household consumption (COICOP), inventory changes and exports. The number of energy commodities to be accounted for should be sufficiently large to reflect the different types and levels of emissions from different types of energy. The use table should also be able to show the use of natural resources – for example, coal, gas and oil extracted by the mining industries.

Figure 4.2. Scope of energy accounts in the case of oil



4.49 In order to construct energy accounts, we must first consider which data is to be used to determine both energy supply and energy use and then how to bring these data together in a balanced system. Each of these issues is discussed in turn below.

Data requirements for the supply table

4.50 With respect to the supply of energy, two main data sources are production statistics and foreign trade statistics. It is important that the nomenclatures of these two sources be absolutely compatible. Both the production and the foreign trade statistics will normally provide data on the monetary value, as measured in basic prices of the energy commodities both produced domestically and imported, as well as the corresponding physical quantities.

4.51 If only monetary values are available, it may be possible for the data to be supplemented with data from the sort of energy balances of the country compiled by the International Energy Agency (IEA).[13] However, some energy types are not commodities in the narrow sense of the word. This applies to many types of renewable energy sources, which are not tradable. Some are provided by the environment, for example, wind. Some may be related to residual flows, such as biogas, wood or other solid waste. The physical supply of such renewables is thus determined by the total use, while the supply in monetary terms is either determined by the unit value of relevant substitutes (or some other "rule of thumb") or set to zero, depending on the corresponding market prices.

4.52 In order to construct the physical energy accounts, the calorific energy content of the energy commodities must be converted to a common unit of energy. Gigajoules or petajoules are the common energy units most often the used by statistical agencies. The unit of account adopted by IEA is the ton of oil equivalent (toe) which is equivalent to 10^7 kilocalories or 41.868 gigajoules. This quantity of energy is, within a few percentage points, equal to the net heat content of 1 ton of crude oil. The difference between "net" and "gross" calorific value for each fuel is the latent heat of vaporization of the water produced during combustion of the fuel. For coal and oil, the net calorific value is 5 per cent less than the gross calorific value.

4.53 An important distinction is made between ***primary energy sources***, separated into fossil fuels and renewable energy sources (such as water power and solar energy), and ***secondary energy sources,*** such as electricity and refined petroleum products which have been produced from the transformation of a primary energy source.

4.54 The physical quantities of each of these need to be converted to a common energy unit and the conversion factors and conventions for doing so are further described below. Since countries exhibit widespread differences in their types of coal, oil and other fossil fuels, conversion factors for each major fossil energy source should be based on country-specific and product-specific information (provided by IEA) in order that the primary energy associated with these products may be calculated. For energy sources such as solar, hydro, wind etc., IEA recommends that the primary energy form be the electricity generated (assuming 100 per cent efficiency). For nuclear and geothermal energy, the primary energy form is assumed (by convention) to be heat and the primary energy equivalent is the amount of heat generated in the reactor or plant (based on certain assumptions about the efficiency of the technology employed to turn heat into electricity). Thus, primary energy equivalents can be calculated, regardless of the sources of energy that are contained in the supply tables. The flow of secondary energy in the supply tables (such as the flow of electricity) can be converted to tons of oil equivalent or joules based on readily available conversion factors.

[13] Data from the International Energy Agency is available via their web site (www.iea.org).

Data requirements for the use table

4.55 The level of disaggregation of the system depends on both the number of energy commodities and the number of industries of the national accounts. Naturally, the usefulness of the system increases with disaggregation, as does the complexity of establishing the system. In the end, establishing a comprehensive focus for the energy use table typically involves combining all sorts of data together with assumptions and well-defined calculation procedures.

4.56 Often definitive information is available at an aggregate or semi-aggregate level and these data are used as control totals in determining entries at a lower level of aggregation. One example of a control total is the total supply of electricity. The sum of all uses must come to exactly this total in physical as well as monetary terms. Such control totals form one very important source of data.

4.57 When determining the use of the different energy commodities by industries and households, the first group of data consists of information from surveys explicitly concerned with energy consumption. In many countries, these are conducted regularly for manufacturing, providing industry-specific data on the use of a number of energy products. Surveys on service industries and households are also conducted in some countries. If such surveys are not conducted yearly, the data must be projected or estimated using various indices and other supporting data.

4.58 In some cases, the survey data include information expressed in both physical quantities and monetary values. If not, accounting data may give more or less detailed information on the amount spent on energy by industry measured in money terms, providing important information on the value dimension of the industry-specific control totals. This, together with information on price statistics, may help determine a control total in physical terms also. In the filling out of the use tables, best use should be made of both physical and monetary data – typically, one dimension is used to determine the other in a supplementary way.[14]

4.59 Another group of data consists of data on specific industries, which can be found in publications of such bodies as umbrella organizations, national monopoly companies, national institutes, trade associations and other agencies concerning the industry in question. Such information may, of course, have to be adjusted for coverage and level of aggregation concerning the different energy commodities.

4.60 There may be other useful registers that provide more or less direct information for the energy accounts system available in a country. For example, some countries have introduced a national CO_2 tax on electricity, which is reimbursed along with the enterprises' VAT payments. Combining such tax data with the business register at the enterprise level may thus contribute to the commodity balance for electricity. In many industries, the use of energy can be formulated as a function of the number of employees within the industry or the total building area as measured in square metres.

4.61 Foreign trade statistics are used as source of information on imports and exports of the different energy commodities. Both monetary values and physical quantities should normally be available. Changes in inventories take into account official data on changes in inventories such as are found in the IEA balances. Differences between alternative sources of information are usually shown as losses, which may include statistical differences as well as ordinary losses due to distribution.

Balancing the system

4.62 Bringing the system into balance means that, for any commodity, the total supply must equal the total use and that, for any industry, the sum of its uses of each of the energy commodities must equal

[14] See the discussion in subsect. A.4 on the differences between quantities and volumes.

some given level, which might be one of the control totals. Furthermore, both dimensions must balance in physical as well as monetary terms (at basic prices) before the system can be pronounced “internally consistent”.

4.63 As the whole system tends to be rather large, it often pays to balance smaller blocks separately before putting the whole system together. Some blocks of industries are known to have a more complex composition of energy use than others. Also, parts of the use table referring to some blocks of industries can be filled out with a greater degree of certainty than others. For example, information is normally plentiful and of good quality concerning manufacturing and the energy transformation industries.

4.64 One example of a commodity-specific block relates to the use of gasoline and diesel fuel. A country's fleet of cars may be listed in a car register, attaching each vehicle to either a person or a business. When applying average conditions, such as yearly kilometres driven and use of fuel per kilometre, to each vehicle type, it is possible to compute theoretical fuel uses for industries or households. These are subsequently scaled to reach the known total uses of each fuel. The physical dimension of accounts for gasoline and diesel can be established in this way. The monetary dimension can be readily established - at least in terms of a first approximation – by applying average basic prices to the physical quantities.

4.65 The balancing of the system thus takes place in stages, by first filling out the parts that are known with a fair degree of certainty and then determining the remainder of the system using progressively less hard data and more assumptions such as employment-based distribution rules. In the whole process, the role of control totals is crucial to controlling the error that may be introduced by inexact assumptions and allocations.

4.66 Consider as another example of control totals, in addition to those already mentioned above, the total energy expenditure by, say, hospitals. The value of the use of all energy commodities by hospitals must equal this total when the whole system is balanced. As yet another example, consider the total output from the district heating industry measured in physical as well as monetary terms, which must exactly equal the sum of the use by households and all other industries in both monetary terms and physical terms.

Energy accounts: the results

4.67 Table 4.4 contains the detailed energy supply and use tables for Denmark. The eight different energy groups shown are an aggregation of 40 energy types in the most detailed supply and use tables for that country. Each group is expressed in its own specific physical unit. Thus, crude oil, coal and lignite, and wood etc. are measured in kilotons, gas is measured in millions of cubic metres, electricity in TWh (terawatt hours, that is, 10^{12} watt hours) and steam and hot water in PJ (petajoules, or 10^{15} joules).

4.68 For each group of energy commodities, the supply table shows domestic production and imports which together make up total supply.

4.69 A distinction is made between primary and secondary energy sources. Primary sources are in the form in which they appear in the environment and thus are identical with natural resources; secondary sources are in the form in which they are finally consumed in the economy and are thus products. Crude oil, natural gas, coal, wood and straw could be shown as natural resources flowing from the environment to the extraction industries of the economy but for this purpose are shown as products that is, as outputs of the economy.

Table 4.4 Supply and use table for energy for Denmark, 1998

Supply table

	Crude oil	Natural gas extracted	Coal and lignite	Petroleum products	Gas to users	Electricity	Steam and hot water	Wood, straw and waste	Total energy supply	
	Thousands of tons	*Millions of m^3*	*Thousands of tons*	*Thousands of tons*	*Millions of m^3*	*TWh*	*PJ*	*Thousands of tons*	*PJ*	*Billions of DKr*[a]
a. Domestic production	11 513	7 314	-	8 007	6 714	42	122	4 557	1 716	53
b. Imports	4 605	-	8 416	6 015	-	3	-	38	654	10
c. Total supply (a+b)	**16 118**	**7 314**	**8 416**	**14 022**	**6 714**	**45**	**122**	**4 595**	**2 370**	**64**

Use table

	Crude oil	Natural gas extracted	Coal and lignite	Petroleum products	Gas to users	Electricity	Steam and hot water	Wood, straw and waste	Total energy use	
	Thousands of tons	*Millions of m^3*	*Thousands of tons*	*Thousands of tons*	*Millions of m^3*	*TWh*	*PJ*	*Thousands of tons*	*PJ*	*Billions of DKr*[a]
a. Intermediate consumption by industries	**7 819**	**7 138**	**9 283**	**6 463**	**3 283**	**25**	**35**	**3 934**	**1 408**	**33**
Agriculture, fishing and quarrying	-	537	105	814	136	2	2	170	76	2
Manufacturing	7 819	-	446	1 153	940	10	6	358	478	11
Electricity, gas and water supply	-	6 601	8 732	1 569	1 890	3	0	3 405	653	9
Construction	-	-	-	331	5	0	-	-	15	0
Wholesale and retail traders	-	-	-	372	106	4	9	-	43	4
Transport, storage and communication	-	-	-	1 892	14	1	1	-	88	3
Financial intermediation	-	-	-	93	45	1	4	-	13	1
Public and personal services	-	-	-	240	147	4	13	-	41	4
b. Inventory changes	**325**	**-**	**-1 100**	**331**	**-128**	**-**	**-**	**-**	**-8**	**0**
c. Private consumption, total	**-**	**-**	**10**	**2 739**	**768**	**10**	**63**	**599**	**256**	**19**
Own account transportation by car	-	-	-	1 842	-	-	-	-	81	2
Heating, use of electricity etc.	-	-	10	897	768	10	63	599	176	17
d. Exports	**7 892**	**-**	**140**	**4 392**	**2 785**	**8**	**-**	**5**	**664**	**11**
e. Losses in distribution etc.	**82**	**176**	**83**	**96**	**6**	**2**	**24**	**57**	**49**	**-**
f. Total use (a+b+c+d+e)	**16 118**	**7 314**	**8 416**	**14 022**	**6 714**	**45**	**122**	**4 595**	**2 370**	**64**

Source: Statistics Denmark.

Note: A dash (-) means that the amount is nil.

[a] Danish kroner.

4.70 For petroleum products, gas to users, electricity, and steam and hot water, the domestic production is a result of the conversion of primary energy types. Thus, there is a double counting in the sense that both primary energy (for example, coal) and the converted energy (for example, electricity produced by coal) are included. This, however, is not different from other monetary or physical supply tables for products in which both raw materials and finished products appear.

4.71 The various units (tons, m^3, TWh and PJ) used for the basic measurement of physical flows of energy can be converted into calorific units, for example, joules. The result of such a conversion carried out at the most detailed level can be seen in the supply table under the heading "Total energy supply" measured in PJ. Further, the last column of the supply table shows the monetary value of the total energy supply in basic prices (billions of Danish kroner (DKr)).

4.72 The use table for energy has exactly the same headings as the supply table. For each group, the total use is equal to the total supply, as shown in the supply table. However, one additional entry, "Losses in distribution etc.", is included in the use table in order to take explicit account of the losses that take place when the energy is distributed from supplier to user by pipe, wire, ship, truck or other means of transportation. As an alternative to the explicit accounting, the physical losses in distribution could be allocated to the users of the energy.

4.73 In the table shown, the intermediate consumption is broken down by eight groups of industries. However, this is an aggregation of a 130-industry classification, which is the same as that used in the Danish national accounts. Thus, the physical supply and use tables for energy are fully consistent with the monetary supply and use tables for energy included in the national accounts and shown in aggregate in the last column of Table 4.4.

Carbon dioxide emissions

4.74 The detailed use table describing energy use by industry and household activities is the basis of the calculation of CO_2 emissions generated by the combustion of fossil fuel. For each entry in the energy supply table, a coefficient showing kilograms of emission per gigajoule of energy specific to the energy type is multiplied by the energy use. The results of such a calculation are shown in Table 4.5. For each energy commodity group, the CO_2 emissions are shown by industry and private consumption (emissions from households). As in the energy tables, private consumption is divided into two separate consumption purposes, own account transportation by car and heating, use of electricity, etc. The accounts for CO_2 emissions related to energy use are part of a broader set of emissions accounts covering other sources also. For some residuals, like methane (CH_4) and nitrous oxide (N_2O), the major part of the total emissions are not related to energy use and the energy accounts therefore must be supplemented by other data to give a full picture. At the most detailed level, these estimates are made according to 40 types of energy product groups and 130 industries. The procedure for calculating emissions is described above.

4.75 For crude oil, electricity, steam and hot water, no emissions are recorded, as no combustion is involved in the direct use of these types of energy. Emissions might have been generated during the production of these energy-containing commodities, if they had been produced by means of fossil fuel combustion. Also, there may be various uses of fossil fuels that will not directly result in emissions of CO_2. Examples are uses related to storage (changes in inventories), exports and losses in distribution. The use of oil products in the production of plastics might be another example, though it is not included in the Danish energy balances.

4.76 In other cases, it might be difficult to track down the energy consumption underlying certain emissions. For example, natural gas platforms may use some of their gas extractions for own account uses. In addition, emissions of CO_2 may result from other processes than fuel combustion. In fact, CO_2 emissions from own account use and from flaring on natural gas platforms are included in the complete set of Danish emissions accounts.

4.77 The CO_2 emissions from combustion are also included for wood, straw and waste in order to give a full picture of the emissions. This is contrary to IPCC guidelines in which the short-term circulation of carbon, inter alia, through the combustion of wood and biochemical processes, is not taken into account because it is supposed that these cycles do not lead to a structural increase in greenhouse gas concentrations in the atmosphere.

Table 4.5. Generation of CO_2 emissions by industry and type of energy use in Denmark, 1998

Kilotons

	Crude oil	Natural gas extracted	Coal and lignite	Petroleum products	Gas to users	Electricity	Steam and hot water	Wood, straw and waste	Total
a. Industries	**-**	**1 210**	**22 726**	**19 139**	**7 352**	**-**	**-**	**5 201**	**55 629**
Agriculture, fishing and quarrying	-	1 210	261	2 589	307	-	-	252	4 619
Manufacturing	-	-	1 123	3 541	2 099	-	-	536	7 299
Electricity, gas and water supply	-	-	21 343	3 884	4 236	-	-	4 413	33 876
Construction	-	-	-	1 074	12	-	-	-	1 086
Wholesale and retail traders	-	-	-	1 113	236	-	-	-	1 349
Transport, storage and communication	-	-	-	5 882	31	-	-	-	5 913
Financial intermediation	-	-	-	289	100	-	-	-	389
Public and personal services	-	-	-	767	330	-	-	-	1 096
b. Inventory changes	-	-	-	-	-	-	-	-	-
c. Private consumption, total	**-**	**-**	**23**	**8 825**	**1 681**	**-**	**-**	**816**	**11 346**
Own account transportation by car	-	-	-	5 994	-	-	-	-	5 994
Heating, use of electricity etc.	-	-	23	2 831	1 681	-	-	816	5 352
d. Exports	-	-	-	-	-	-	-	-	-
e. Losses in distribution etc.	-	-	-	-	-	-	-	-	-
f. Total emissions (a+b+c+d+e)	**-**	**1 210**	**22 750**	**27 964**	**9 033**	**-**	**-**	**6 018**	**66 974**

Source: Statistics Denmark.

Note: A dash (-) means that the amount is nil.

5. Accounts for emissions: Netherlands

4.78 In the Netherlands, emissions are compiled and recorded in one central database called the Netherlands Pollutant Emission Register. This annual reporting system contains a substantial amount of data on residuals released to air and water and land. Several institutes are jointly responsible for the collection and compilation of these data: the Ministry of the Environment, Statistics Netherlands, the Government Institute for Public Health and the Environment (RIVM) and the Netherlands Organisation for Applied Scientific Research (TNO).

4.79 The Netherlands Pollutant Emission Register combines two estimation procedures. The biggest residual sources in the Netherlands are observed directly. Supplementary estimates are made for the smaller sources, including mobile sources such as traffic. The relationships between the different sources are reviewed in Figure 4.3 which refers to the compilation of air emissions.

4.80 The Netherlands energy balance (Energy Supply in the Netherlands (ESN)) is used to estimate emissions for smaller combustion processes by grossing up the air emission data which are originally measured at a sample of emission sources. Air emissions from stationary (point) and mobile sources are recorded separately, as different methodologies are followed for each. In the case of stationary sources, Statistics Netherlands is responsible for the estimation of emission totals specified by branch of industry.

4.81 As already noted, emission inventories often make use of process-oriented classifications of emission sources. A reclassification is required in order to connect this information to the national accounts. This reclassification to industries is less complex for processes connected to stationary sources. For mobile sources, much supplementary information is required to allocate the corresponding emissions to industries. Air emission estimates from mobile sources rely on both energy and transport statistics. In the case of road vehicles the emissions are estimated on the basis of data on, inter alia:

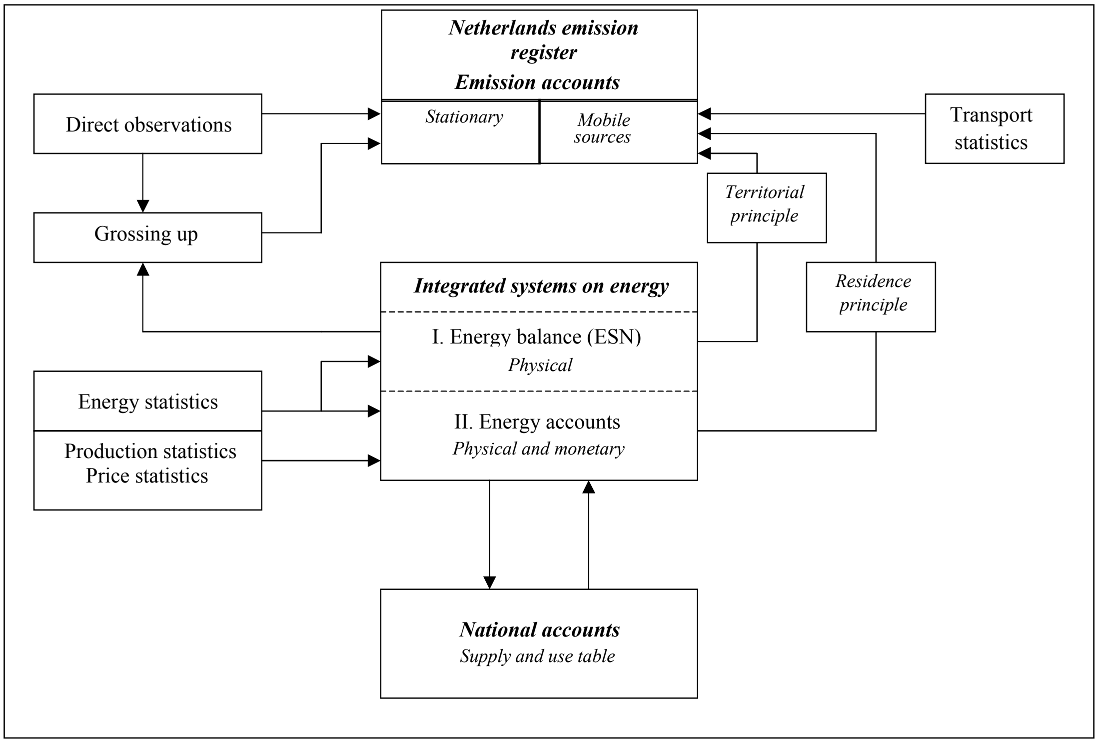
(a) Fuel types (gasoline, diesel, liquid petroleum gas);

(b) Annual kilometres driven;

(c) Type of driving (on rural roads, inner city, highways);

(d) Technical data on engines.

Figure 4.3. Compilation of air emission statistics in the Netherlands



Source: Statistics Netherlands.

4.82 Information on the use and consumption of fuels comes from the energy balances but is not specified by industry. In order to compile the emissions from mobile sources according to economic activities as presented in the hybrid account, supplementary estimates are made by integrating the data on energy consumption from the ESN with the supply and use tables of the national accounts. Monetary data on fuel purchases by industry are converted into physical volumes with the help of price information in such a way as to ensure full consistency with the ESN.

4.83 As already mentioned, emission inventories and national accounts usually differ in scope. Emission inventories focus usually on emission sources within the national territory, whether by resident or non-resident units. The national accounts measure emissions by resident units whether operating within the national territory or abroad. These differences in scope are largely determined by differences in the compilation of mobile emissions. The difference between emissions on national territory and emissions as compiled in the physical flow accounts is made up by:

(a) Additions of emissions by residents in the rest of the world;

(b) Deductions of emissions by non-residents on national territory.

4.84 On the basis of the Netherlands Pollutant Emission Register system, a number of different CO_2 figures are published annually in the Netherlands, each used for different purposes. These different numbers are summarized in Table 4.6 together with their relationship to one another. The differences are due solely to differences in definitions and not to statistical discrepancies.

Table 4.6. CO_2 emissions in the Netherlands, 1995-1998

Millions of tons

		1995	1996	1997	1998
1.	**Total: IPCC (Kyoto Protocol)**	**177**	**185**	**183**	**183**
2.	Temperature correction	3	-5	3	3
3.	**Total: annual environment report (RIVM)**	**180**	**180**	**186**	**186**
1.	**Total: IPCC (Kyoto Protocol)**	**177**	**185**	**183**	**183**
4.	Emissions related to short-term carbon cycles (wood burning)	4	5	4	4
5.	Statistical discrepancies in the ESN energy balance	-2	-3	-6	-4
6.	Potential CO_2 from the combustion of plastics	-3	-3	-2	-3
7.	**Total actual emission in the Netherlands (CBS[a])**	**177**	**184**	**179**	**181**
8.	Residents in the rest of the world	23	23	25	26
9.	Non-residents in Netherlands	-4	-3	-4	-3
10.	**Total emissions by residents in Netherlands (CBS[a])**	**196**	**204**	**201**	**203**

Source: Statistics Netherlands.

Note: Figures may not add due to rounding.

[a] Central Bureau of Statistics

4.85 First, for the purpose of international climate policies, IPCC has developed guidelines on the basis of which the emissions of greenhouse gases and so-called indirect greenhouse gases can be calculated and reported for each individual country. According to the IPCC guidelines, figures for international bunkers for civil aviation and marine transport are reported separately from national totals. However, in the agreements on reductions for countries or regions as laid down in the Kyoto Protocol (United Nations, 1997b) to the United Nations Framework Convention on Climate Change (United Nations, 1994), residual emissions from international transport have not been taken into consideration.

4.86 RIVM publishes the IPCC total corrected for changes in the annual average temperatures. In this way, the data are not influenced by incidental effects such as relatively cold or mild winters, thus introducing the possibility of monitoring structural changes.

4.87 Statistics Netherlands publishes the actual emissions of CO_2. In contrast to the IPCC figure, the temperature corrections are excluded. Then, emissions related to the combustion of wood in wood-burning stoves are added. Statistical differences related to the ESN are removed. Lastly, the emissions attributed to the future combustion of plastics are subtracted. (The IPCC guidelines consider wood burning stoves etc. (short carbon cycles) a non-structural contribution to the greenhouse gas problem.)

4.88 Table 4.6 also shows the estimates made by Statistics Netherlands for emissions in the country by non-residents and by residents abroad (see Verduin (2000) for further details). The definition of residency that is used is consistent with the one in the national accounts and allows for a comparison with aggregates such as GDP.

Emission flows relative to the rest of the world

4.89 The importance of the adjustment for the emissions to and from the rest of the world can be observed from Table 4.6; 13 per cent of the emissions by residents in 1998 was generated outside the Netherlands owing to international transport.

4.90 Accounting for air transport, water transport and transport via railways is normally a fairly easy task in that the energy use for these purposes is confined to only a limited number of (ISIC) industries. For example, civil aviation will usually be completely attributed to the activity "air transport", while military aviation carried out by the defence forces is typically part of public administration. The emissions related to road transport, on the other hand, constitute a more complex issue because the emissions are not restricted to a single industry but rather arise from specific transport service industries as well as from own account transportation in all other industries and by households.

4.91 The emissions related to road transport thus depend on the distribution of the country's fleet of vehicles between different industries and households and their patterns of usage. When designed appropriately, commodity balances for the different fuel types will include use of each fuel type by households and each industry. This information may be estimated from energy balance information. If this is not available, it could be estimated by a simple allocation procedure, for example, by utilization of central car registers in combination with assumptions concerning average distances driven (km/year), or average usage of fuel (litre/km) for each type of car or vehicle. Additional data sources that can be applied for the allocation of emissions from transport to economic activities are the following:

(a) Purchases of motor car fuels and use of vehicle maintenance services;

(b) Information on the links between the car register and the business register;

(c) Transport statistics;

(d) Fuel taxes.

Most of this information may already have been used in the compilation of the supply and use table. When a supply and use table does not provide sufficient detail, information on fuel tax payments may be used instead, at least to separate transport emissions related to households from those related to production.

4.92 There are various possible emission sources other than transportation where the relationship of the emission to the ISIC classification is not straightforward, for example, non-methane volatile organic compound (NM-VOC) emissions from spray cans, (fire) extinguishers, cooling systems etc. Here also, supplementary data sources are usually needed to allocate emissions to industry branches.

4.93 Table 4.7 -Table 4.9 illustrate the differences between emissions as they are usually compiled in emissions inventories and emissions estimates in relation to the national accounts.

Table 4.7. Emissions to air as compiled in Netherlands emission inventory (national territory)

Kilotons

	CO_2	N_2O	CH_4	NO_X	SO_2
Stationary sources					
Production					
Agriculture and mining	13 420	7	73	56	22
Fishing	-	-	-	-	-
Manufacturing, electricity and construction	106 348	41	452	220	138
Transport, road	-	-	-	-	-
Transport, air	-	-	-	-	-
Transport, water	-	-	-	-	-
Other services	5 052	7	137	3	2
Consumption	25 080	4	20	26	1
Mobile sources					
Road transport	27 084	6	5	202	9
Air transport	70	-	-	21	-
Water transport	5 976	1	1	77	18
Other sources	990	-	477	-	-
Total	184 020	66	1 165	605	190

Source: Statistics Netherlands

Note: A dash (-) indicates that the amount is nil.

Table 4.8. Emissions to air as compiled in Netherlands physical flow accounts (national economy)

Kilotons

	CO_2	N_2O	CH_4	NO_X	SO_2
Production					
Agriculture and mining	14 320	7	73	61	23
Fishing	3 700	-	-	25	12
Manufacturing, electricity and construction	111 398	42	452	275	139
Transport services, road	6 644	2	1	60	4
Transport services, air	9 620	-	-	40	2
Transport services, water	10 036	3	1	83	33
Other services	8 102	8	137	33	4
Consumption					
Transport	14 640	3	4	88	3
Other	25 080	4	20	26	1
Other sources	990	-	477	-	-
Total	204 530	69	1 165	691	221

Source: Statistics Netherlands.

Note: A dash (-) indicates that the amount is nil.

Table 4.9. Reconciliation of emissions by residents and emissions (national territory)

Kilotons

	CO_2	N_2O	CH_4	NO_X	SO_2
Emission by residents	204 530	69	1 165	691	221
Residents in the rest of the world (-)	24 080	3	-	134	45
Road transport	4 830	1	-	52	3
Air transport	9 890	-	-	20	2
Water transport	9 360	2	-	62	40
Non residents on domestic territory (+)	3 570	-	-	48	14
Road transport	1 630	-	-	16	1
Air transport	340	-	-	1	-
Water transport	1 600	-	-	31	13
Emission on national territory	184 020	66	1 165	605	190

Source: Statistics Netherlands.

Note: A dash (-) indicates that the amount is nil.

Environmental themes

4.94 In order to assess the cumulative impact of a number of different flows on the same environmental phenomenon, it is possible to introduce alternative classifications or units of account to represent certain quality aspects of these flows. For example, conversion factors may be used to show how much of one substance has the same impact as a single unit of another substance. In this way, these substance-based quantity units can indicate the relative potential stress on the environment caused by individual substances in relation to particular environmental concerns. Subsequently, these equivalents can be used for weighting and aggregating a number of substances into one indicator. Adriaanse (1993) first introduced this systematic compilation of so-called environmental theme indicators. The themes presented in Table 4.10 correspond to the key environmental problem fields identified in the Netherlands national environmental policy plans.

4.95 Examples of environmental theme-oriented weighting were given in the overview of chapter III. Potential impact evaluation of toxic residuals as regularly carried out in life-cycle analysis can also be applied in environmental accounting. Besides its toxicity, the dispersion patterns and degradability of a given residual also influence its expected effects on human health and ecosystems. Dispersion models are used to determine the expected residual concentrations in the various environmental domains (air, water and land/soil). The expected toxic impacts of certain residuals on human health or distributed between terrestrial and aquatic ecosystems may differ considerably, so that a number of indicators may be required to cover these various impacts.

4.96 Such theme indicators, compiled on the basis of scientific knowledge, explicitly underline the multiple characters of environmental concerns. They are calculated by taking the volume figures in Table 4.9 and multiplying them by the conversion factors in Table 4.10. Some conversion factors are internationally agreed constants; some vary from country to country.

Table 4.10. Factors for converting residuals into theme-equivalents

Theme / Residual	Greenhouse effect	Ozone layer depletion	Ground-level ozone formation	Acidification[a]	Eutrophication	Toxic dispersion
CO_2	1					
N_2O	310					
CH_4	21		0.014			
HFCs	140 – 11 700					
PFCs	6 500 – 9 200					
SF_6	Specific					
CFC12	8 500	1				
CFC13	5 000	1				
CFC113	9 300	0.8				
CFC114	9 200	1				
CFC115	-	0.6				
Halon 1211	5 600	3				
Halon 1301	5 600	10				
Carbon tetrachloride	Specific	Specific				Specific
1,1,1-trichloroethane	Specific	Specific				Specific
NM-VOCs	Indirect		1			
SO_2	Indirect			$^1/_{32}$ or 0.03125		
NO_X	Indirect		1.22	$^1/_{46}$ or 0.0217	Specific	
NH_3				$^1/_{17}$ or 0.0588	Specific	
CO	Indirect		0.11			
Nutrients						
Phosphorus					Specific	
Nitrogen					Specific	
Metals						
Cadmium						NOEC
Copper						NOEC
Lead						NOEC
Organic compounds						
Benzene						NOEC
Naphthalene						NOEC
PCDF						NOEC
PAH						NOEC

Sources: Global warming potential: Intergovernmental Panel on Climate Change (IPCC) (1995); ozone layer depletion: World Meteorological Organization (1998); acidification: Schneider and Bresser (1988); ground-level ozone formation: de Leeuw (2002); and toxic dispersion: Guinee and others (1996).

Note: NOEC: No-observable-effect concentration.

[a] Acidification equivalents derived from molecular weights.

4.97 Two examples of conversion are presented in Table 4.11. One entails the conversion of greenhouse gas emissions into CO_2 equivalent emissions using global warming potentials as the conversion factor; the other example involves the conversion of the accumulation of acidification residuals in the national environment. The first column in the table shows the quantity of residuals generated; the second column shows the conversion factor used; and the third column shows the resulting aggregate effect in a common numeraire. The last column, containing percentage shares, indicates the relative contribution of each of the residuals to the theme in question.

4.98 It should be emphasized that the theme indicators reflect the potential stress on the environment. Combinations of various stresses as well as spatial and timing considerations will together usually determine the actual environmental consequences of these different stress categories. Thus, environmental theme indicators contribute to a compact representation of environmental pressures without the necessity of oversimplification.

Table 4.11. Conversion of residuals by weight into theme-equivalents

Global warming theme				
	Emissions (kg)	GWP factor (CO_2 conversion factor)	CO_2 equivalents (kg)	Percentage shares
CO_2	204 530	1	204 530	81.69
N_2O	69	310	21 390	8.54
CH_4	1 165	21	24 465	9.77
Total			250 385	100.00
Acidification theme				
	Accumulation (kg)	Acidification equivalent	Acid equivalents (moles of H^+ ions)	Percentage shares
NO_X	100	0.0313	3.1300	26.87
SO_2	108	0.0217	2.3436	20.12
NH_3	105	0.0588	6.1740	53.01
Total			11.6476	100.00

Source: Statistics Netherlands.

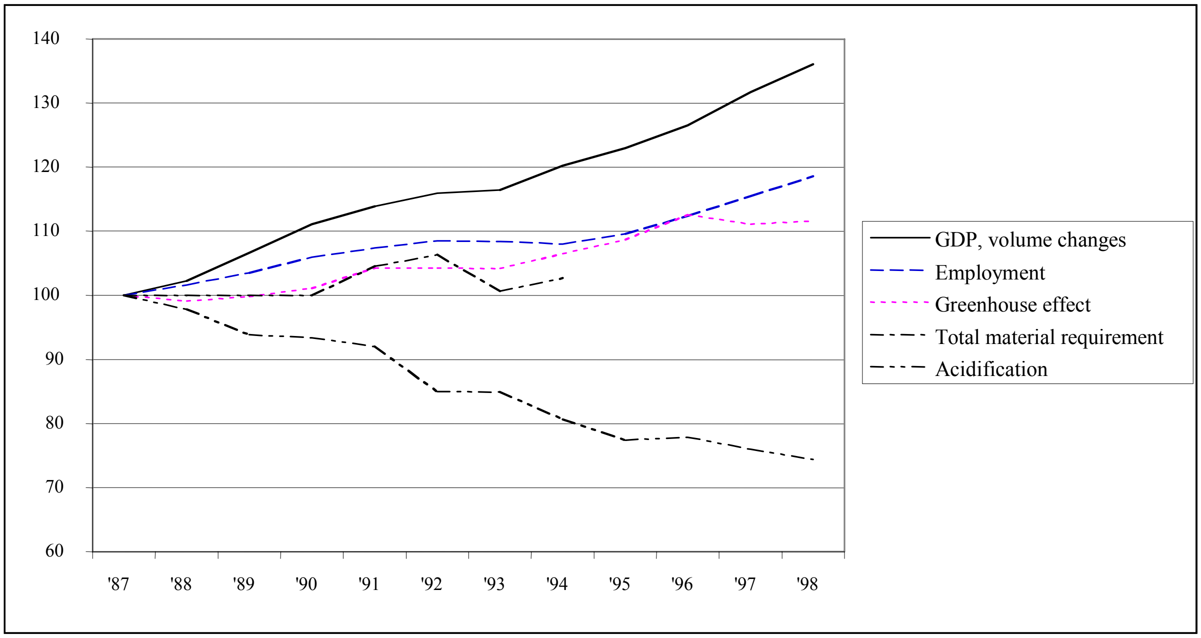
Comparing economic and environmental indicators

4.99 Already in some countries, environmental indicators regularly supplement the national accounts aggregates. Aggregate indicators such as GDP, unemployment and environmental theme indicators together provide a compact set of indicators that review the economic performance at the macrolevel. These indicators can also be presented at a sectoral level and provide the basis for so-called environmental-economic profiles. Besides monitoring the developments of environmental and economic indicators in detail, these profiles also demonstrate the importance of the economic structure. Economies dominated by services industries will show totally different residual emission patterns when compared with economies where agriculture or manufacturing industries predominate.

4.100 Environmental indicators drawn from the hybrid accounts framework supplement the time trends of national accounts figures with comparable time trends of resource use, residual emissions, and environmental degradation, both in total and by industry. The overview of economic and environmental trends helps us assess whether we are achieving national goals, typically set in terms of total figures for residual emissions or resource use. Figure 4.4 provides an example of such an overview of economic development for the Netherlands between 1987 and 1998. GDP and employment grew by about 35 per cent and 20 per cent, respectively, while the emission of most residuals grew more slowly, or – in the case of residuals contributing to acidification – even declined. Figures similar to Figure 4.4 for other environmental themes may be constructed; for example, different sets of environmental variables (for example, energy and water) may be shown side by side with economic variables (for example, GDP and employment).

Figure 4.4. Macro-indicators for economic and environmental performance of the Netherlands, 1987-1998

Index 1987 =100



Source: Statistics Netherlands (1999); and Adriaanse and others (1997).

Environmental-economic profiles

4.101 While the aggregate figures provide a useful overview of trends in the economy, more detailed information tells us where progress has been made over time and where obstacles still remain, thereby setting the stage for future action. The formulation of policy requires taking into account both the environmental burden imposed by an industry and its economic contribution. Environmental-economic profiles, or "eco-efficiency" profiles, have been compiled by a number of countries in order to assist in identifying environmental priorities. The profiles combine economic contribution and environmental burden by industry. The economic contribution is represented, for example, by the percentage share of each industry in GDP or employment. The environmental burden is represented by the percentage share of each industry in the emission of various residuals, or the use of materials and energy.

4.102 In the Netherlands, the profile revealed a very unequal distribution across industries of economic benefits such as employment and value added on the one hand, and environmental burdens in terms of the environmental theme indicators on the other. The striking environmental burden imposed by agriculture compared with its relatively low economic contribution made the headlines in Netherlands newspapers and elsewhere. The profiles show that total residuals emissions are determined not only by the size of a national economy but also by its structure.

4.103 Table 4.12 shows the net percentage contributions to the economy and to environmental themes by each economic activity and by final consumers (households and government). The economic contribution for economic activities is represented by value added and for final consumers by total consumption expenditure. The contributions to environmental themes are calculated by using more detailed versions of tables like Table 4.8 and Table 4.10. Reading across the first few rows of the table, it is clear that industrial activity accounts for the majority of all residual emissions (66-97 per cent), although final consumers are responsible for a considerable share of greenhouse gases (19 per cent) and solid waste (31 per cent). Final consumption is further disaggregated into two components, own transport and all other consumption. While own transport accounts for only 8 per cent of household spending, it accounts for a disproportionate share of most household emissions: 38 per cent of greenhouse gas emissions: 88 per cent of acidification emissions and 21 per cent of eutrophication emissions.

Table 4.12. Net contribution of consumption and production to GDP and to six environmental themes in the Netherlands, 1993

Percentage

	Economy	Environment				
		Greenhouse effect	Ozone layer depletion	Acidification	Eutrophication	Solid waste
Total		100	100	100	100	100
Consumption		19	2	15	9	31
Industry		79	97	85	91	66
Capital and other sources		2	1	-	-	3
Consumption	100	100	100	100	100	100
Own transport	8	38	-	88	21	1
Other consumption	92	62	100	12	79	99
Production	100	100	100	100	100	100
Agriculture, hunting, forestry, fishing	3	15	2	47	91	7
Mining and quarrying	3	2	-	1	-	1
Manufacturing						
Petroleum industry	1	7	-	11	-	
Chemical industry	2	14	27	6	2	16
Metal products and machinery industry	3	2	9	1	-	2
Other manufacturing	12	12	20	7	6	25
Public utilities	2	26	-	9	1	2
Transport and storage	6	8	6	12	1	5
Other services	68	14	36	6	-1	42

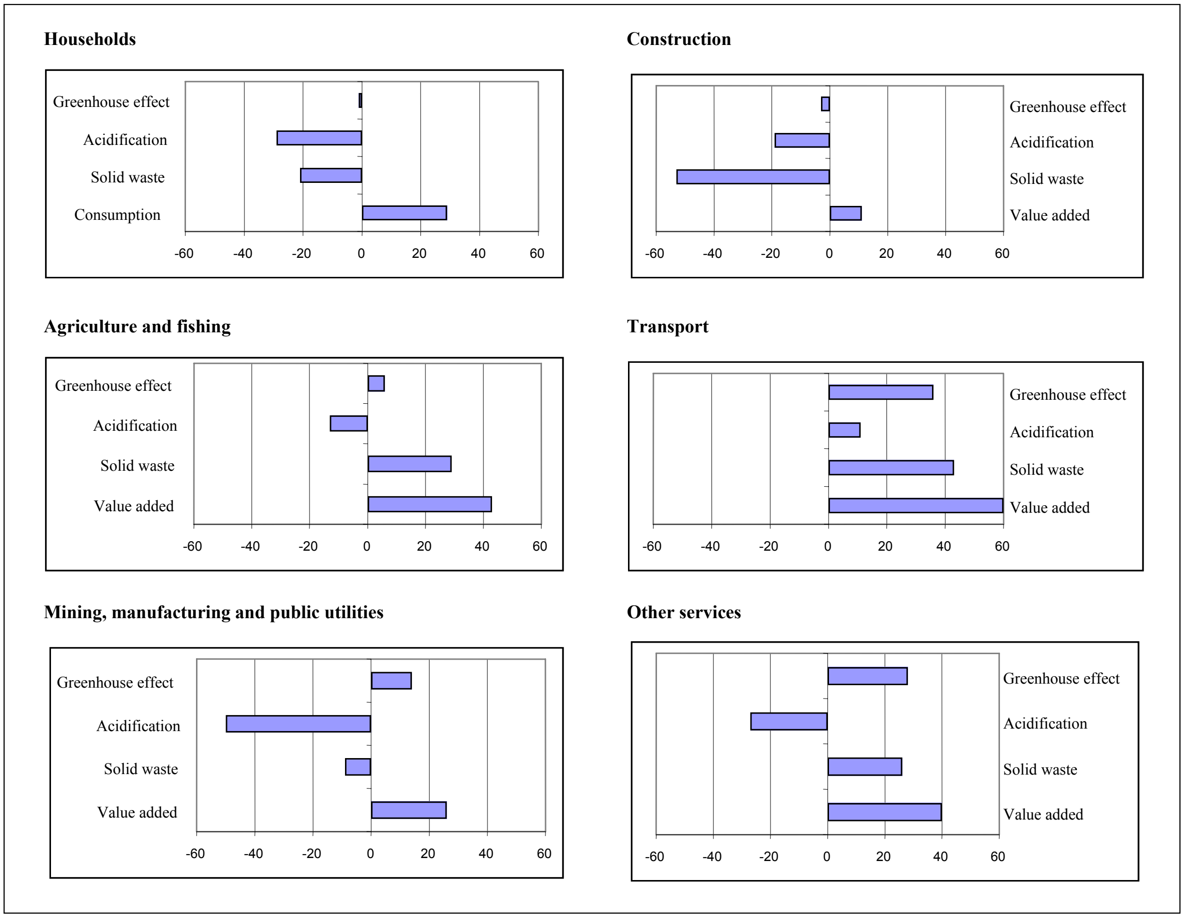
Source: de Haan (1997).

Note: A dash (-) indicates that the amount is nil.

4.104 Among industries, the importance of the structure of production is apparent. A large share of residual emissions is produced by a relatively few industries, but the figure is not at all proportional to their economic contribution as represented by their shares of value added. In terms of greenhouse gas emissions, for example, three industries account for 55 per cent of emissions: agriculture (15 per cent), chemicals (14 per cent) and public utilities (26 per cent); however, their combined contribution to GDP is only 7 per cent. Agriculture alone accounts for 47 per cent of acidification and 91 per cent of eutrophication emissions.

4.105 It is also important to track these profiles over time in order to determine whether an industry's performance is improving or not. Figure 4.5 shows changes between 1987 and 1998 for value added and emissions in the Netherlands for selected industries. Although agriculture was identified as a major source of residual emissions in Table 4.12, the data in Figure 4.5 indicate that the industry has done a great deal to reduce emissions. Value added increased more than 40 per cent over the period, but all emissions grew much less, and acidification emissions actually declined despite the increase in production. The only industry for which all emissions increased is transport services, but even here, emissions did not increase as rapidly as value added.

Figure 4.5. Changes in environmental profiles for households and selected industries in the Netherlands, 1987-1998



Source: de Haan (1997).

4.106 This simple analysis of descriptive statistics can be carried out for resource use, such as energy and water inputs, or other environmental impacts. For designing environmental policy, it may also be useful to disaggregate the accounts spatially within a country. Environmental burdens of residuals with a highly localized impact, such as eutrophication, may be very unevenly distributed nationwide. Similarly, the economic impacts of environmental policy may have a very uneven impact. A database that is spatially disaggregated would allow the identification of these dissimilar regional impacts.

4.107 Environmental-economic profiles are being used in Norway for "benchmarking" industry performance, a useful tool both for national environmental policy and for environmental management at the company level (Hass and Sørenson, 1998). The environmental performance of companies or industries is compared with that of cleaner, more efficient companies or industries in the same country or in other countries. The performance of an industry over time is also monitored. The first set of benchmark indicators for Norway was developed for air pollutants; this approach is now being expanded to include environmental issues such as solid waste and waste water. Within EU, benchmarking may be quite useful as a means to monitor progress of member countries towards common environmental goals.

C. Input-output analysis

4.108 The present section reviews some of the non-technical details of environmental input-output analysis. It discusses the research questions that can be solved by way of input-output analysis without presenting the mathematical backgrounds. More extensive and more technical descriptions of the techniques involved can be found in a number of works on input-output, for example, *Handbook of Input-Output Tables: Compilation and Analysis* (United Nations, 1999a) and in the academic literature (for example, Miller and Blair (1985) and Konijn (1994)).

1. Supply and use versus input-output

4.109 Section A mentioned the possibility of using either supply and use tables or input-output tables for augmenting the national accounts with physical flow data. The differences between these two formats are briefly explained on the basis of Table 4.13.

4.110 An input-output table is a single table constructed by using the supply table to transform the use table into one where the intermediate consumption sub-matrix is square and consists of either products used to make products or industry output used by industries. Suppose that industry A produces two products, X and Y, and that X accounts for 90 per cent of the total production and Y, the remaining 10 per cent. The simplest, "industry technology" assumption is to say that exactly 90 per cent of all inputs are required to produce X and 10 per cent are required to produce Y. This assumption is consistent with assuming that, for A, Y is a by-product always produced in connection with X and that no extra inputs to process Y are required. If the assumption is valid, it is relatively straightforward to simply reallocate all by-product production to an industry that has this product as its main product. This process may not be based on very robust technological data, but it is bound to result in a matrix that seems more or less plausible. Even if there is no industry that produces Y as a main product, an artificial industry can be created by attributing to it all the by-product production from different industries.

4.111 The alternative simple "product technology" assumption considers that all Y is produced in a manner identical to that involving the inputs for an industry that produces only Y – industry B, say. Then, based on the pattern of the inputs of B, the proportion needed to make an amount of Y equal to 10 per cent of the output of A is calculated. By deduction, the remaining inputs must be those used to produce only X. It is quickly apparent that this assumption, though in many ways more intuitively appealing than the "industry technology" assumption, can run into practical difficulties. If A simply does not use enough of a given input to meet the requirement according to the "product technology", there will be a negative amount left as input for the manufacture of X.

4.112 All the means of producing an input-output table amount entail reaching a compromise between these two assumptions on a product-by-product or industry-by-industry basis subject to plausibility constraints, such as the fact that negative inputs are impossible by definition. So, while an input-output table has much greater analytical power because it links use and demand directly, it is further removed from the basic data and involves an amount of manipulation based on partial information and subjective judgements. However, it should be remembered that the basic data for supply and use tables do not fall neatly and automatically into balanced tables and also require applied intelligence on the part of the table compilers. This may encompass implications arising from the exercise of producing an input-output table.

4.113 This transformation of the supply and use tables into a single input-output table has the following result: supply and use for each product or industry are equal, that is, the row totals and column totals match pair-wise. For this reason, such tables are called "symmetric" tables. Because supply and use are not only equal but linked by the same classification and equal within the same table, a number of powerful analytical tools drawing on the properties of this type of "symmetric" matrix become available. The power of these techniques for purely economic studies of the linkages between industries has been known and used for a considerable period of time. The possibility of linking economic and environmental issues has been suggested for some time but practical application is somewhat newer.

2. An input-output table

4.114 Table 4.13 is the monetary industry-by-industry input-output equivalent of the monetary supply and use table shown in Table 4.2. Instead of being expressed in terms of products, use is expressed in terms of demand on the output of industries. In consequence, the first set of columns showing which products are made by which industries also ceases to appear. In effect, the upper right and lower left segments of Table 4.2 have been consolidated into the lower right segment of the table. The row and column totals for this new, compact matrix are equal and equal to the row and column totals for industries in Table 4.2. The entries for value added are unchanged, since they still relate to industries. The other entries are close to the figure that would result from the conversion that assigned products to the industry most likely to produce them, but are not exactly so because of the role of imports. In practice, more variation is to be expected because of the role of secondary production (for example, some agricultural enterprises make manufactured food from their own products).

Table 4.13. The monetary industry by industry input-output table

Billions of currency units

	Industries				Final consumption	Capital formation	ROW exports	Total use
	I1	I2	I3	**I**	C	CF	X	
I1 Agriculture, fishing and mining	*19.1*	*96.8*	*14.0*	*129.9*	*30.9*	*2.9*	*65.7*	*229.4*
I2 Manufacturing, electricity and construction	*28.4*	*205.7*	*30.2*	*264.3*	*204.2*	*62.9*	*158.6*	*690.0*
I3 Services	*11.3*	*90.1*	*13.5*	*114.9*	*151.9*	*28.3*	*71.9*	*367.0*
I Total industries	*58.8*	*392.5*	*57.7*	*509.0*	*387.0*	*94.2*	*296.2*	*1 286.4*
M ROW Imports	*15.8*	*99.7*	*14.1*	*129.6*	*95.2*	*47.0*	*91.2*	*363.0*
Taxes on products	*3.2*	*19.0*	*3.1*	*25.3*	*24.2*	*4.8*	*15.6*	*70.0*
Total final uses (purchasers value)					*506.4*	*146.0*	*403.0*	*1 719.4*
Value added (basic value)	*151.6*	*178.8*	*292.0*	*622.4*				
Total production (basic value)	*229.4*	*690.0*	*367.0*	*1 286.4*				

Source: SEEAland data set.

4.115 As in the monetary supply and use table, there is a row showing the effect of taxes on products. In this format, though, the trade and transport margins are no longer immediately obvious. As a result of collapsing the product dimension to an industry, one means that all margins are included in the services entries. The GDP identities can be derived from this table, as from the supply and use table. The value is still 692.4 which can be calculated as either the sum of final use (capital formation [146], final consumption [506.4], exports [403]) less imports (363) or as value added (622.4) plus taxes on products (70).

4.116 Just as the monetary supply and use table (Table 4.2) can be combined with the physical supply and use table (Table 3.12) to give a hybrid supply and use table (Table 4.3), so Table 4.13 can be combined with the physical input-output table (Table 3.25) to form a hybrid input-output table. This is shown in Table 4.14. For reasons of space, the non-monetary flows are shown in total only, although, clearly, in practice these would be detailed as in earlier tables. No distinction is made in this table between the national and the rest of the world environment as either origin or destination of flows. They are presented in summary form as in Figure 4.1. Clearly, this dimension also can be added and cross-boundary flows from one environment to the other also shown. As before, the monetary entries are shown in italics.

Table 4.14. The hybrid industry-by-industry input-output table

Billions of currency units (entries in italics) or millions of tons

	Industries				Final consumption	Capital formation	ROW exports	Total use	Residuals
	I1	I2	I3	**I**	C	CF	X		R
I1 Agriculture, fishing and mining	*19.1*	*96.8*	*14.0*	*129.9*	*30.9*	*2.9*	*65.7*	*229.4*	35.240
I2 Manufacturing, electricity and construction	*28.4*	*205.7*	*30.2*	*264.3*	*204.2*	*62.9*	*158.6*	*690.0*	186.680
I3 Services	*11.3*	*90.1*	*13.5*	*114.9*	*151.9*	*28.3*	*71.9*	*367.0*	57.925
I Total industries	*58.8*	*392.5*	*57.7*	*509.0*	*387.0*	*94.2*	*296.2*	*1 286.4*	279.845
M ROW imports	*15.8*	*99.7*	*14.1*	*129.6*	*95.2*	*47.0*	*91.2*	*363.0*	5.756
Taxes on products	*3.2*	*19.0*	*3.1*	*25.3*	*24.2*	*4.8*	*15.6*	*70.0*	
Total final uses (purchasers value)					*506.4*	*146.0*	*403.0*	*1 719.4*	
Value added (basic value)	*151.6*	*178.8*	*292.0*	*622.4*					
Total production (basic value)	*229.4*	*690.0*	*367.0*	*1 286.4*					
Capital formation									72.595
Final consumption									48.206
N Natural resources	196.000	65.000		261.000	2.000		1.000		
E Ecosystem inputs	15.000	81.000	25.000	121.000	24.000		2.000		
Absorption of residuals	0.240	2.680	3.925	6.845		25.810	5.332		

Source: SEEAland data set.

4.117 Besides this industry-by-industry version of the input-output table, it is also possible to construct a product-by-product version. This is of less interest in the SEEA context, since all inputs of environmental resources and outputs of residuals are available classified by industry and not by product.

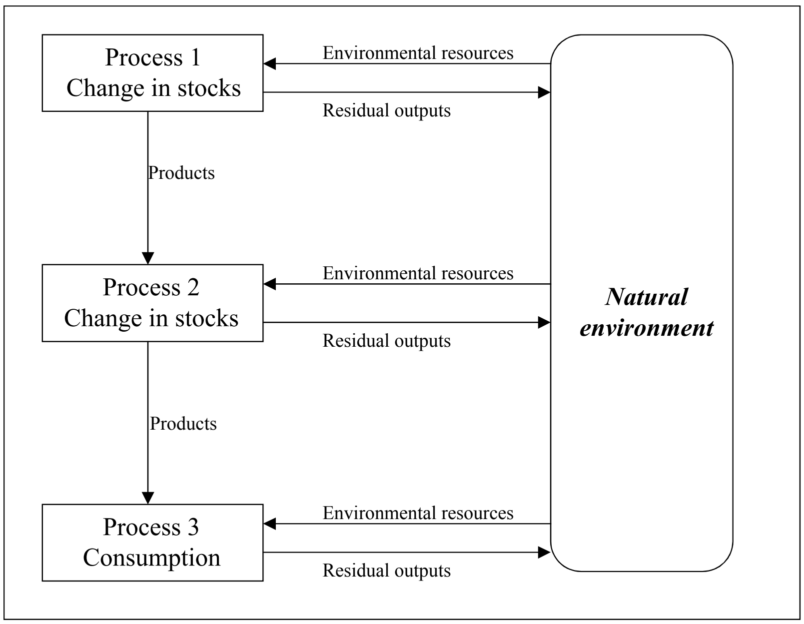
4.118 It is important to remember that both hybrid supply and use tables and hybrid input-output tables can in principle be represented by two types of accounting units, namely, physical and monetary. Depending on the scope of the analysis, material flows within establishments (at the level of industrial processes) may also be of concern in order to provide a comprehensive description of transformation processes and their environmental consequences. These internal flows do not appear as product transactions in the monetary supply and use table and the only way to reveal them is to deal with "products" at an even more detailed level. Sometimes supplementary units may be required as well in analysing physical flows. An interesting example in this respect is the account on biological metabolism in the physical input-output table for Germany (Stahmer and others 1996) in which different biological flows are distinguished, such as cultivated plants and animals, forests, pets and human beings.

3. Environmental requirements of products

4.119 Emission accounts show the *direct* residual emissions generated by various production and consumption activities. Obviously, the output of an industry can be compared with the emissions generated in this industry; but this comparison does not show the *indirect* resource inputs or residual outputs that were generated during the production of the required intermediate deliveries. Thus, accounting for the direct environmental performance of an economy has certain limitations, in that the accounts do not immediately reveal the quantity of material used or residuals generated during the whole production cycle of a certain product or service. In other words, a complete product chain has to be taken into consideration before the direct and indirect environmental impacts of goods and services can be estimated.

4.120 Figure 4.6 presents such a product chain. Process 1 delivers the raw or supplementary materials required in process 2. Process 2 delivers a final product to a consumption process indicated by process 3. The product flows indicate how to allocate resource inputs or residual outputs to final user. In Figure 4.6, this allocation is fairly straightforward. Without changes in stocks, the direct and indirect environmental requirements of process 3, that is, consumption, is equal to the summation of all resource inputs or residual outputs across all the processes. Although the consumer is obviously neither the extractor nor the emitter of all resource inputs and residual outputs, all the environmental requirements in the product chain have served the provision of a consumer good. Therefore, all these requirements can be attributed to the consumption of this good. Obviously, the consumption process itself may also rely on residual emissions or resource extractions.

Figure 4.6. A simple product chain



4.121 A systematic allocation of environmental requirements becomes increasingly complicated when processes are interconnected, for example, when products flow in both directions between processes. Simple examples of these interconnections are represented by the following:

(a) Steel is required to produce machinery while machinery is needed to produce steel;

(b) The extraction of crude oil may require a substantial amount of energy.

The input-output table typically reveals these interconnections and input-output analysis can subsequently be used to allocate emissions systematically from production processes to final products.

4.122 Table 4.15 shows the results of such an input-output analysis in which the total (direct and indirect) energy requirements are estimated for a number of products. The 10 products supplied in the Netherlands with the highest energy requirements are presented in this table (energy commodities such as oil, heating fuel, electricity etc. are excluded from this ranking). Energy (or material) requirements are not necessarily embodied in products. For example, the high energy requirement of fish results from the substantial energy used in cooling and transportation. Besides energy, it is also possible to analyse the total material requirements (water, plastics, steel etc.) or even the residual requirements (CO_2, NO_X, solid waste etc.) of final products.

4.123 In analysing the total material or energy requirements of final products, special attention should be paid to the problem of double counting. It is to be expected that energy accounts or balances as presented in this chapter will include a substantial amount of double counting. After all, one particular quantity of natural resource extracted may be converted several times in a number of successive production processes. As a result, the supply and use of this particular quantity of material may be represented several times in different product groups in the supply and use table. For example, crude oil may be converted to refined petroleum products; and some of these may be further used in the production of electricity, which is then further supplied to the final consumers of energy. This production chain for electricity shows the number of times the energy content is counted in a successive number of energy products. When these energy or material accounts are connected to monetary input-output tables in order to estimate the energy requirements per money unit of final product, as presented in Table 4.15, the result will be an overestimation of the energy requirements of the product.

Table 4.15. Energy intensities of products in the Netherlands, 1993

Product	**Energy intensity of product** (Kilojoules per guilder)
Fertilizers	64.6
Plastics	34.8
Steel	23.2
Fish	23.2
Bricks and tiles	22.7
Zinc	22.2
Aluminium	20.6
Greenhouse vegetables	20.5
Ores	19.8
Pulp	19.6

Source: Konijn and others (1997).

4.124 Physical input-output tables are helpful in eliminating this double counting. Physical input-output tables separate natural resources or ecosystem inputs directly extracted from the natural environment, from product flows within the economic sphere. Physical input-output tables and analysis allow for the estimation of the physical quantity of natural resource inputs required to produce one physical unit of product. In this way, environmental inputs are allocated to the successive stages of processing. Double counting can thus be avoided, since all products are expressed in terms of the quantity of raw materials needed for production. The analysis of the energy or material requirements of products as presented in Table 4.15 usually relies on a combination of physical and monetary input-output analysis.

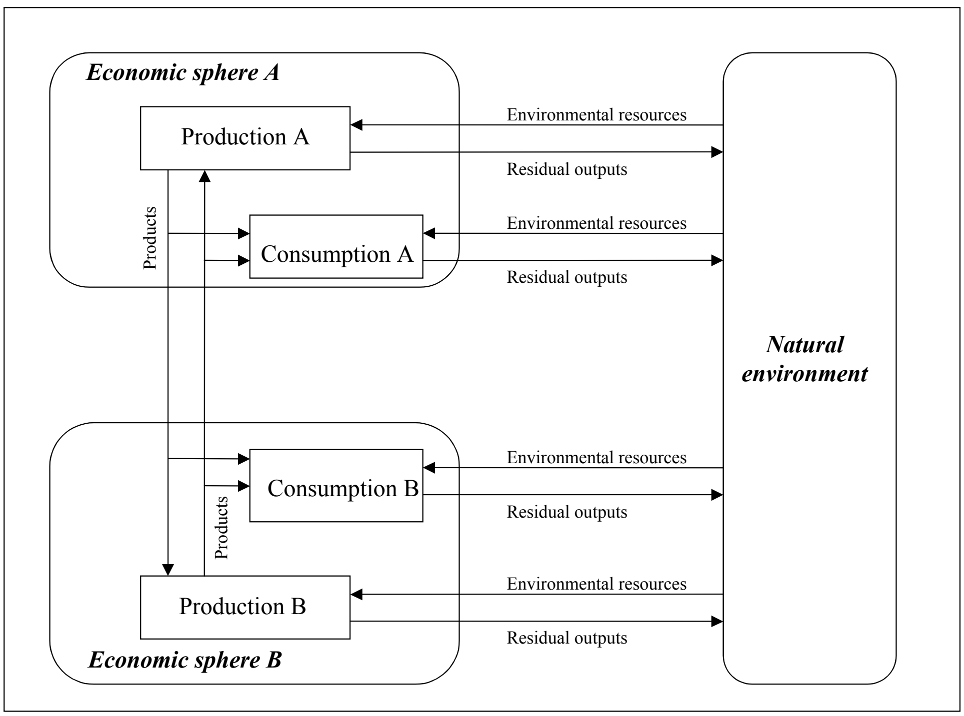
4.125 As already mentioned, the analysis presented in Table 4.15 can also be calculated for the residuals (kilograms of CO_2, for example) required for the production of one monetary unit of final product. However, in such an analysis, it seems theoretically sound to use the concept of net residual outputs, that is, gross outputs of residuals minus the reabsorption of residuals within the economic sphere through processes such as incineration, recycling and wastewater treatment. If the matrices of gross residual outputs (A) and residual inputs (B) have identical dimensions (residual by industry), the subtraction of B from A will provide the appropriate net emission matrix suitable for the analysis. Some of the entries in this net residual output matrix corresponding to the specialized pollution abatement activities such as waste (water) treatment in plants may show negative pollution coefficients.

4. Environmental requirements of consumption

4.126 The analysis given in the previous section shows the environmental requirements of production. It is also interesting to determine the environmental requirements of consumption. These two will be exactly the same only in a closed economy with neither imports nor exports. International trade exists because different countries have different comparative advantages in terms of economic criteria. As they also have different environmental requirements for production, it would be interesting to determine the total environmental impact of consumption, taking into account that part due to imports and that part due to domestic production. In the same way, of course, some environmental requirements will be the result of production for exports; and this too should be noted with a view to further analysis.

4.127 This impact of international trade flows is illustrated by Figure 4.7 which represents two countries, A and B, with reciprocal trade relations. Each country includes production and consumption processes and each process interacts directly with the environment via natural resource inputs and residual outputs.

Figure 4.7. Allocation of indirect environmental requirements



4.128 So-called import matrices may be compiled to provide this information. Import matrices combine both dimensions into one table that shows the type of imported product used as either intermediate consumption by industry or final demand (consumption or capital formation.)

4.129 In the standard supply and use or input-output table, imports appear in a single column in the supply table or in a single row in the input-output table. The column in the supply table contains imports classified by product groups. The specific users of these imports are not identified in the use table. The import row in the input-output table shows the total value of import by industries and households (and government) regardless of the type of product or service that is being imported or used. Hence, in the input-output table, the user is identified, while the type of product is not. The type of product and the user of imports have both to be identified in order that the indirect environmental effects of imports in an economy may be analysed.

4.130 Ideally, information on imports would also be broken down by different importing countries. Then, if the environmental requirements for each product imported were available for the country of origin, an adjustment could be made with respect to the environmental requirements of production by adding the requirements of imports and deducting the requirements of exports so as to reveal the requirements of consumption. Comparisons could also be made to determine whether the demand on the global environment made by exports was greater or less than the demand made by imports.

4.131 In practice, however, detail at this level of detail is unlikely to be available. Within EU, some information may be available for imports from other EU countries with matching hybrid accounts. In general, however, either one of two simplifying assumptions is made.

4.132 The first assumption is that the environmental requirements of imports, product by product, correspond to the requirements of the domestic production of the same product. This will often be unsatisfactory and of course impossible in the case where there is no domestic production of an imported product.

4.133 Table 4.16 provides a macroeconomic overview of all direct and indirect CO_2 emissions of domestic production and consumption activities and imports and exports in the Netherlands. Direct emissions are those associated with a production or consumption process. Indirect emissions are those associated with the production of the products used in a consumption or production process. In this analysis, the direct emissions from national production are supplemented with the foreign direct emissions connected to imports. This total amount of 309 million tons of CO_2 is subsequently distributed to the final demand categories of consumption, capital formation and exports. In this way, the origin of CO_2 emissions is identified together with the purpose or the kind of use to which the CO_2 generating products can be attributed. In this way, all CO_2 emissions can ultimately be attributed to a final demand category.

Table 4.16. Allocation of CO_2 emissions to final demand in the Netherlands, 1997

Millions of tons

Origin	
Domestic	
Production (direct)	164
Consumption (direct)	36
Rest of the world	
Imports (indirect)	109
Total, origin	309
Causation	
Domestic	
Consumption (direct + indirect)	132
Capital formation (indirect)	27
Rest of the world	
Exports (indirect)	150
Total, destination	309

Source: Statistics Netherlands.

4.134 The direct emissions produced by households are linked to the purpose of their consumption. Direct emissions from imports and production are systematically allocated, or indirectly attributed, to the final users by way of input-output analysis. In this example, the substantial amount of CO_2 attributed to imports and exports reveals the very open economic structure of the Netherlands. A substantial quantity of residual emissions attributed to consumption is generated in other countries, while a similarly substantial quantity of domestic emissions is attributed to exports. This shows that in the Netherlands residual emissions from domestic production are only partially related to domestic consumption. This example underlines the importance of a consistent treatment of environmental emissions related to international trade when looking at the indirect effects of consumption.

4.135 Analysing the indirect environmental effects of imports has another important policy implication. When, from one year to the next, a product whose production process has environmentally hazardous consequences is no longer produced domestically but is imported from abroad, environmental accounting will indicate this substitution as an improvement in the environmental performance of the domestic economy. However, for the environment, this substitution may not be optimal, since the material use or residual emission is only exported abroad and not necessarily diminished. Analysing the so-called environmental rucksacks of imports may reveal this export of polluting industries.

Time-series analysis

4.136 The sections above looked at the patterns of residuals arising from different processes and different countries. It is obviously also very important to investigate how these patterns change over time. One technique used in time-series analysis is structural decomposition analysis. This is a means of showing how much of the total change in residual generation is due to each of a number of specified causes. A simple case is to determine the degree to which changes in emissions by vehicles are due to the increase in kilometres driven and how much this increase is abated by improvements in technology that reduce emissions per kilometre. Structural decomposition analysis can be used to analyse the annual changes in residual emissions and material uses for an entire economy. It may identify the key driving forces that influence the development of material consumption and residual emissions over time.

4.137 Obviously, a comparison of environmental and economic data over time must abstract from the pure effect of price changes so that economic changes may be captured in terms of volume changes. To this end, input-output tables in constant prices are necessary. Efficiency changes, as measured by the total material input or residual output per monetary unit of production or consumption, may also affect the emissions of residuals in time. Here, too, a time series of input-output tables is necessary to examine the effect of changing efficiencies and determine whether efficiency gains can compensate for increases in resource consumption or residual emissions triggered by economic growth.

4.138 Illustrations may be given of effects that can be explicitly presented in decomposition analyses. For example:

(a) Input-output analyses can be used to estimate the changes in environmental requirements that have been caused by the volume and type of growth in final expenditure;

(b) With respect to air emissions, a further decomposition could be made involving changes in fuel mix on the one hand and changes in emissions per unit of fuel combusted on the other, as illustrated by the following equation:

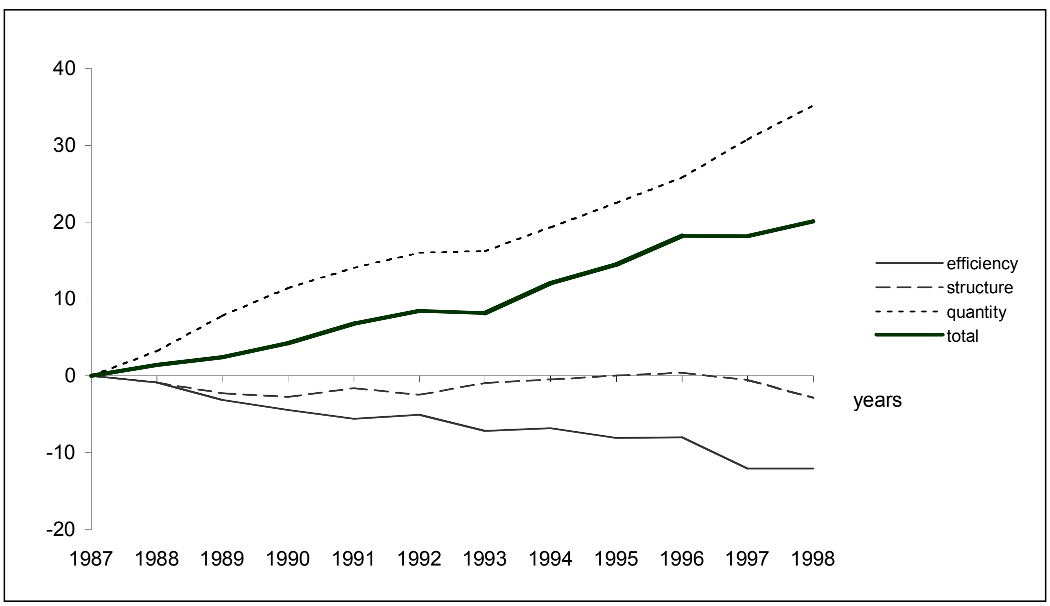
$$\text{residual}_x = \text{fuel}_y * \text{emission factor}_{x, y, z}$$

4.139 Changes in the structure of the economy may also partly influence changes in emissions. Input-output tables help to trace these structural effects. Many of the world's economies are shifting from manufacturing towards the production of services. The environmental consequences of this structural effect may be substantial since the production of services will have different environmental consequences as compared with manufacturing. Also, when incomes grow, differences in consumer propensities towards various products will lead to a changing economic structure. Another example of possible structural change, already referred to, entails the relocation of highly polluting industries to other countries (with less strict environmental legislation). A structural decomposition analysis that includes the indirect effects from imports should reveal this relocation of polluting industries.

4.140 Figure 4.8 illustrates a structural decomposition analysis of production-related CO_2 emissions in the Netherlands. The change in the output of CO_2 emissions was less than the increase in production owing to the fact that efficiency gains had led to a decrease in emissions per unit. Changes in structure had a small but not continuous effect on keeping the level of emissions down. Structural changes are rather inconclusive. The shift towards a service economy did not lead to a decline in residual emissions. Further, in spite of efficiency gains of more than 12 per cent, emissions increased between 1987 and 1998 by 20 per cent.

4.141 Table 4.17 below compares the results of decomposition analyses for CO_2 emissions for the Netherlands and the United Kingdom of Great Britain and Northern Ireland with the provision of some extra detail. The results show that the factors driving emissions changes can differ substantially across countries. For example, the substantial reduction in the emissions from the electricity, gas and water supply industry of the United Kingdom was mainly due to fuel switching (increased use of natural gas), whereas in the Netherlands electricity was generated using mainly natural gas throughout the period covered. The increase in emissions of the Netherlands sewage and refuse disposal industry is mainly explained by increased incineration of waste.

Figure 4.8. Decomposition of changes in production-related CO_2 emissions in the Netherlands, 1987-1998



Source: de Haan (2001).

4.142 Table 4.17 also illustrates the fact that in both economies the structural change component made a relatively small net contribution to emission reduction at the aggregate level; however, the table also makes clear that this masked the impact of a substantial structural change within certain sectors, such as agriculture, mining, manufacturing and electricity supply, which was largely cancelled out by structural changes within the services sectors, in particular the increased residual emissions from transport services.

4.143 Obviously, the identification of these different driving forces provides a good starting point for scanning the possible future developments in the physical economy, taking explicitly into consideration expectations regarding economic growth, technical improvements and structural changes.

Table 4.17. Decomposition of the change in CO_2 emissions by industries in the Netherlands and the United Kingdom of Great Britain and Northern Ireland

(Percentage of total change relative to the base years)

	Netherlands, 1987-1999				United Kingdom, 1990-1998			
	Efficiency change	Structural change	Economic growth	**Total change**	Efficiency change	Structural change	Economic growth	**Total change**
Agriculture, forestry, fisheries	**-0.2**	**-1.8**	**3.0**	**1.0**	**0.1**	**-0.2**	**0.2**	**0.1**
Crude petroleum and natural gas production	*0.6*	*-0.2*	*0.4*	***0.8***	*-1.1*	*1.3*	*0.8*	***0.9***
Manufacture of petroleum products	*-0.5*	*-1.0*	*2.5*	***1.0***	*-0.4*	*-0.1*	*0.8*	***0.3***
Manufacture of chemical products	*-5.1*	*0.3*	*5.0*	***0.2***	*0.0*	*-0.3*	*0.5*	***0.3***
Manufacture of basic metals	*-0.5*	*-0.2*	*1.7*	***0.9***	*0.2*	*-1.3*	*1.0*	***-0.1***
Other mining and manufacturing	*-1.3*	*-0.6*	*3.0*	*1.1*	*-1.0*	*-2.5*	*1.8*	*-1.7*
Mining and manufacturing	**-6.8**	**-1.7**	**12.6**	**4.1**	**-2.3**	**-3.0**	**5.0**	**-0.3**
Electricity, gas and water supply	**1.2**	**-4.4**	**9.7**	**6.5**	**-14.7**	**-0.8**	**5.3**	**-10.2**
Land transport	*-0.8*	*0.5*	*1.7*	***1.4***	*-0.8*	*0.2*	*0.9*	***0.3***
Water transport	*-0.2*	*0.3*	*1.4*	***1.5***	*0.1*	*0.1*	*0.4*	***0.5***
Air transport	*-3.1*	*3.3*	*2.0*	***2.2***	*-1.0*	*2.4*	*0.8*	***2.2***
Sewage and refuse disposal	*0.7*	*0.9*	*0.8*	***2.4***	*-0.2*	*0.1*	*0.0*	***-0.1***
Other services and construction	*-2.9*	*0.0*	*3.9*	*1.0*	*-1.9*	*0.2*	*1.8*	*0.1*
Total services and construction	**-6.3**	**5.1**	**9.8**	**8.6**	**-3.8**	**2.9**	**3.9**	**3.1**
Total change in CO_2 emissions	**-12.1**	**-2.9**	**35.1**	**20.2**	**-20.7**	**-1.1**	**14.4**	**-7.4**

Sources: Adapted from de Haan (2001) and Harris (2001).

Chapter V. Accounting for economic activities and products related to the environment

A. Overview

1. Objectives

5.1 Chapters III and IV have discussed how to augment conventional national accounts by appending information on the manner in which the environment provides inputs to and absorbs outputs from the economic process. The present chapter together with chapter VI shows how to identify those transactions within the economy that are directly concerned with using, managing and protecting the environment. The present chapter works mainly within the supply and use framework established in the previous chapters. Chapter VI goes beyond product-related transactions to consider other economic instruments affecting the environment.

5.2 The SNA encourages the development of satellite accounts in order to study particular parts of the economy in greater depth. This is carried out by defining the activities and products that are "characteristic" of the field of study. In this case, it is activities and products concerned with the environment that are of interest. Within the present context, no new transactions or even rearrangements of the basic SNA identities and definitions of aggregates are considered; however, later chapters do consider variations and additions to the basic SNA structure in the context of an external satellite account.

5.3 The difference between products and industries was introduced in chapter III. Products flow from industries to other industries, to consumers and into capital accumulation. All products originating in the national economy come from industries. However, when we wish to identify those industries and products that are characteristic of the environment, the simple industry and product classifications are not sufficient. We need to introduce alternative classifications to discriminate between those products and industries frequently associated with environmental activity. Then we need to identify when these and possibly other products are actually used to achieve environmental goals. This is done by introducing a classification of activity by purpose.

The environmental domain of interest

5.4 The two main purposes designated to be of environmental interest are protection of the environment and the management of natural resources and their exploitation. In addition, there are some activities that, though not primarily aimed at protecting the environment, may have environmentally beneficial effects. Damage avoidance and treatment may also be included in the field of interest, though these activities are more concerned with rectifying damage already done than with preventing it in the first place. Lastly, and perhaps less obviously, activities aimed at minimizing natural hazards may be included, although these are activities undertaken to protect the economy from the environment, whereas the others are concerned with protecting the environment from the economy. For simplicity's sake, the expression "environmental activity" is used throughout this chapter as shorthand for all the environment-related purposes just described.

5.5 Once the purposes of economic activity of interest are identified, it is possible to construct accounts showing the supply of the relevant products and the nature of the expenditure on them. The accounts can show whether the environmental activities are being undertaken by private enterprises or government and the extent to which the costs are incurred by industry, by government and by consumers. They also provide the setting within which to explore the potential impact on production patterns and residual generation of new technologies, especially those designed to be more environmentally friendly.

Use of the accounts

5.6 The reason for establishing accounts for environmental protection and resource management is to identify and measure society's response to environmental concerns through the supply and demand for environment goods and services, through the adoption of production and consumption behaviour aimed at preventing environmental degradation and by managing environmental resources in a sustainable way. The accounts presented in this chapter systematically identify those parts of the national accounts that are relevant to this objective. This means that the analysis, though strictly consistent with the national accounts as currently compiled, identifies separately the relevant transactions that have actually taken place.

5.7 The accounts can be used to analyse: (a) the effects of economic policy measures on environmental activities and issues and (b) future scenarios. Policy interest is often broader than just environmental protection. For example, water-related policy may include wastewater management, water purification and supply, water saving, management of rivers and flood control. The accounts can also be used more simply to derive indicators that highlight change in key areas such as resources spent on pollution prevention and abatement and associated savings, the contribution that the environment protection industry makes to economic growth, and the shift to pollution preventing technologies.

5.8 Another way of using environmental protection and resource management accounts entails modelling the effects of possible changes in environmental measures, in order to estimate the way such changes will affect (directly and indirectly) environmental pressure, economic activity, growth and employment in the future. A particular use of such models may be to estimate the effect on GDP, employment and trade of a given level of environmental protection measures. This is explored in chapter X as part of the question how to try to measure the economic costs of preventing the remaining environmental damage.

5.9 A further, immediate use of environmental protection and resource management accounts is the production of indicators that illustrate how actions to remedy the environmental impact of the economy are changing over time. Chapter XI explores the subject of indicators based on the accounts presented in this chapter as well as other possible uses.

2. Introducing purpose classifications

5.10 So far (in chaps. III and IV), the classifications used have been those showing what is produced (products) and by whom (industries). The first step in identifying environmental activity is to subdivide products and industries into those that are typical, or characteristic, of environmental activity, and those that are not, which can be done by subdividing the rows and columns for products and industries in the supply and use table. However, this does not completely solve the problem because products typical of environmental activity may in fact be used for other purposes and some non-typical products may be used by environmental activities. For example, a unit undertaking street cleaning and refuse collection may buy overalls for its workers, even though overalls are not considered to be typically environmental products. Similarly, the vehicles used to collect refuse will typically be manufactured by a producer who also makes non-environmental vehicles.

5.11 In order to include the overalls bought for refuse collection and exclude the non-environmental vehicles, we introduce a further classification into the matrix, one where the purpose of the expenditure undertaken is identified. This too is subdivided to show the purposes that are environmental in nature, and thus of interest here, and other purposes. In this case, the purposes of interest are those listed above: protection of the environment, management and exploitation of natural resources, environmentally beneficial activities and the minimization of natural hazards.

5.12 Table 5.1 shows a supply and use table with both these extra classifications added. (For simplicity's sake, at this stage we assume a closed economy with no imports and exports.) The first pair of rows shows the same information on consumption and accumulation classified by products as appears in chapters III and IV, but now there is a distinction between environmental and other products and categories of expenditure. The refuse collection vehicles appear as environmental capital formation of environmental products. The overalls purchased by the refuse collection industry fall in the column for environmental intermediate consumption but in the row for non-environmental products. To take a slightly far-fetched example, if some machinery incorporating the latest environment-friendly technology is bought for display in a museum rather than put to use protecting the environment, it would appear in the row for environmental products and in the column the for non-environmental capital formation.

Table 5.1. Products, purposes and industries

<table>
<tr><td colspan="3" rowspan="3"></td><td colspan="6">Production</td><td colspan="3">Consumption</td><td colspan="2">Accumulation</td></tr>
<tr><td colspan="2">Products</td><td colspan="2">Purposes</td><td colspan="2">Industries</td><td colspan="2">Industries</td><td rowspan="2">Consumers</td><td colspan="2">Industries</td></tr>
<tr><td>Environmental</td><td>Other</td><td>Environmental</td><td>Other</td><td>Environmental</td><td>Other</td><td>Environmental</td><td>Other</td><td>Environmental</td><td>Other</td></tr>
<tr><td rowspan="6">Production</td><td rowspan="2">Products</td><td>Environ-mental</td><td colspan="6" rowspan="2"></td><td colspan="2" rowspan="2">Intermediate consumption of products classified by industry</td><td rowspan="2">Final use by product</td><td colspan="2" rowspan="2">Capital formation of products classified by industry</td></tr>
<tr><td>Other</td></tr>
<tr><td rowspan="2">Purposes</td><td>Environ-mental</td><td colspan="4" rowspan="2"></td><td colspan="2" rowspan="2">Output of industries by purpose</td><td colspan="5" rowspan="2"></td></tr>
<tr><td>Other</td></tr>
<tr><td rowspan="2">Industries</td><td>Environ-mental</td><td colspan="2" rowspan="2">Output of products by industries</td><td colspan="9" rowspan="2"></td></tr>
<tr><td>Other</td></tr>
<tr><td rowspan="3">Consumption</td><td rowspan="2">Industries</td><td>Environ-mental</td><td colspan="2" rowspan="5"></td><td colspan="2" rowspan="2">Intermediate consumption by industries classified by purpose</td><td colspan="7" rowspan="5"></td></tr>
<tr><td>Other</td></tr>
<tr><td colspan="2">Consumers</td><td colspan="2">Final use by purpose</td></tr>
<tr><td rowspan="2">Accumulation</td><td rowspan="2">Industries</td><td>Environ-mental</td><td colspan="2" rowspan="2">Capital formation by industries classified by purpose</td></tr>
<tr><td>Other</td></tr>
</table>

5.13 Just as the entries for consumption and accumulation classified by products are disaggregated between those that are environmentally relevant and those that are not, so the entries in the first pair of columns where output is shown by industry (as described and utilized in chapters III and IV) are similarly disaggregated between environmental and other industries. As in all such matrix presentations, the sum values of the entries in the row for environmental products must equal the sum of values of the entries in the column for the output of environmental products. In this presentation, though, we can see which of these products is made by environmental industries and which by other industries. An important instance of environmental products coming from non-environmental industries arises from the fact that many industries undertake environmental protection activities on their own account, for example, clean-up activities which constitute an example of what are known as ancillary activities. In addition, some environmental industries may carry out significant production of non-environmental products, representing what is known as secondary production. How to delineate environmental activity and the appropriate treatment of ancillary activity and secondary production are the subject of section B, which discusses classifications of activities according to environmental purpose and elaborates the measurement of activities and products concerned with one of these purposes, environmental protection.

5.14 At this point, we introduce the second extension of the matrix, the pair of rows and columns showing the purpose of supply and use. As before, the row and column sums for these new rows and columns must be equal pairwise, but by introducing this further classification we have moved the overalls into the environmental purpose classification and excluded the environmental vehicles going to the museums. Ideally, what we want to measure are the expenditures connected with the designated environmental purposes. For practical reasons concerning available data sources, though, we may be constrained to look at environmental industries or environmental products. This matrix presentation is intended to show that while there is a large overlap between environmental industries, environmental products and environmental purposes, there exist activities and products that may fall within only one or two of these groups. Much of the work of determining environmental protection expenditure is concerned with identifying where the boundaries of interest lie.

5.15 Strictly speaking, the match between supply and use by purpose will be achieved only in a closed economy or one where imports and exports are exactly balanced. In practice, it is difficult if not impossible to know whether imported products originated in environmental industries and it is not possible to know the purpose intended for exports. For this reason, purpose classifications are used as subsidiary classifications and there is usually some ambiguity concerning imports and exports.

3. Environmental protection expenditure accounts (EPEA)

5.16 Although the desired scope of accounts concerned with environmental activity encompasses resource management and exploitation, damage avoidance and treatment and minimization of natural hazards in addition to environmental protection, in many countries accounts have been developed only for environmental protection expenditure. For this reason, much of this chapter, and in particular section C, concentrates on this single aspect of environmental activity. It is hoped and assumed that the techniques developed here will provide useful examples for work in other areas of environmental activity. Some prototype work suggests this may be so but this has yet to be confirmed in more general implementation.

5.17 Section C discusses not only how to measure the supply and use of environmental products but also the expenditure on them. Identifying expenditure on environmental protection in the same framework as expenditure on education and health, say, is a necessary precondition to making an assessment of the balance of relative costs and benefits and the trade-off between areas encompassing different aspects of economic and social life. Section C elaborates a concept of national expenditure on environmental protection as the sum of all uses of environmental protection products plus gross capital formation undertaken by those producing these goods and services adjusted for payments from government and the rest of the world. It then discusses how the costs of this expenditure are financed.

5.18 Section C also discusses some of the data issues that arise when compiling the accounts.

5.19 Section D presents two examples of the compilation of accounts in this area. The first example of compilation concerns an environmental input-output table for Germany concentrating on environmental protection expenditure; the second, an account for research and development expenditure on environmental protection in Canada. In addition, two extensions of the accounts are briefly discussed, one establishing a link to physical data and the other establishing time series for environmental protection in constant prices.

4. Scope and limitations of the accounts

5.20 The need in a particular country for the accounts described here will vary, reflecting differences in national characteristics and political priorities (for example, some countries will have a special interest in water supply, others in forestry management, and many will have an interest in energy savings, waste minimization and recycling). Hence each country may wish to define the scope of environment-related activities in its own way. For developing countries that have a high tourist income from people visiting game parks, protection of wildlife will have a greater priority than in many other countries.

5.21 Several countries have put some of the accounts presented in this chapter into practice. Data collection and reporting at the international level are in place for some of the undertakings mentioned, for example, the Joint Organisation for Economic Co-operation and Development (OECD)/Eurostat survey on Environmental Protection Expenditure and Revenues (EPER) and other environmental protection activities. Many countries have already implemented the Environmental Protection Expenditure Account described in this chapter. Data-collection activity is also being undertaken on the "environment industry" so as to gain a complete picture of environmental protection activities as well as of the role of environmental taxes. So far, there is less practical experience with the other accounts, in particular resource management accounts.

5.22 However, besides drawing attention to the uses of the accounts, it is necessary to point out some of their limitations. These result mainly from classification, definitional and data-collection issues. As with other satellite accounts, there are problems with respect to defining the scope of different environment-related protection activities precisely. The scope of the coverage is important when carrying out subsequent analyses by environmental protection domain, or by resource categories, or when analysing the effect of environmental taxes.

5.23 One of the most difficult determinations to be made is whether the primary purpose of the spending is environmental protection, or whether environmental protection is simply a consequence of decisions taken for some other purpose, for example, spending on equipment may reduce pollutant emissions but may also be more energy-efficient. There are also practical data-collection problems to consider such as trying to estimate the cost of the additional "clean" part of new capital equipment, particularly where the clean element becomes a standard part of the equipment and there is no "dirty" alternative.

5.24 There are difficulties in linking environmental spending directly with physical reductions in residual emissions. It may be possible for solid waste but difficult where a number of environmental benefits may result, affecting different media. However, such linkages substantially enhance the value of the information by enabling average or marginal pollution abatement costs to be calculated.

B. Environmental activities and products

1. Environmental activities and purpose classifications

5.25 Environmental activities are those that reduce or eliminate pressures on the environment and aim at making more efficient use of natural resources. Examples are investing in technologies designed to prevent or reduce pollution,[15] restoring the environment after it has been polluted, protecting the economy from a deteriorated environment, recycling, conservation and resource management and the production of environmental goods and services. Environmental protection activities include only those activities whose primary purpose is environmental protection and not those that, though beneficial to the environment, serve other purposes (such as energy-saving equipment).

5.26 The statistical coverage of all environmental activities is still evolving. For the present, the following groups are considered:

(a) Environmental protection activities;

(b) Natural resource management and exploitation activities;

(c) Environmentally beneficial activities;

(d) Minimization of natural hazards.

5.27 Each of these is considered in turn below.

5.28 In addition, there are activities aimed at avoiding or treating damage from a polluted environment. Examples include expenditure associated with moving from one's house or changing one's place of work to avoid local noise or air pollution; expenditure on cleaning and restoring dirty or damaged buildings resulting from air pollution; and hospital treatment for people adversely affected by poor environments. In practice, however, the identification and estimation of damage avoidance and treatment present substantial difficulties and for this reason are not discussed further until chapter IX.

Environmental protection activities

5.29 Environmental protection activities are those whose primary purpose is the protection of the environment, that is, the avoidance of the negative effects on the environment produced by economic activities. Examples include spending by companies on end-of-pipe equipment to reduce or eliminate emissions or make them less hazardous, and spending on environmentally protective technology to minimize emissions and pollutant discharges during the production process. By convention, this heading also includes spending on those technologies where only part of the new equipment has an environmentally beneficial component. For example, the fact that equipment may need replacing at the end of its life is the reason for the investment, but the primary purpose of the "clean" element is to protect the environment. The activities are generally classified by the environmental "domains" that are protected, for example, air, water, soil and groundwater, biodiversity and landscape. The full Classification of Environmental Protection Activities and Expenditure (CEPA) is given in annex V.

5.30 Relevant activities and expenditures are identified by the criterion of the primary purpose. Along with this "primary purpose" definition, there are several variants or subsets that have been used either in combination or separately. The following criteria may also be adapted to identify other environment-related activities and expenditure:

> ***The pure purpose criterion.*** Activities and expenditure whose main objective is protecting the environment are included in full. This criterion works best in cases where the main objective of protecting the environment is clear and unambiguous, for example, end-of-pipe capital expenditure.

[15] Such technologies, and the corresponding products, are sometimes more colloquially referred to as "environment-friendly", "clean" or "cleaner". The last two terms are sometimes used in the tables in this chapter simply to keep the headings of manageable length.

The extra-cost criterion is used to identify the portion of the cost of more environmentally friendly technologies and changes in processes and products to be attributed to environmental protection. The investment and operating expenditure are compared with those of a "standard" or less environmentally beneficial alternative, if there is one, or the estimated additional cost of incorporating the environmentally beneficial feature. Only the extra expenditure is included.

The net-cost criterion. Only expenditure undertaken for environmental protection purposes that leads to a net increase in cost (that is, in cases where spending exceeds any savings or income arising before the net cost was actually incurred) is included. When expenditure is recorded, this criterion applies only to operating expenditure.

The compliance criterion. Expenditure undertaken with the main objective of protecting the environment but specifically in order to comply with environmental protection legislation, conventions and voluntary agreements. This can be further subdivided to show those activities and transactions undertaken in order to comply with legislation only.

5.31 These guidelines do not form an exhaustive, mutually exclusive set. They are simply a practical set of working definitions that have been adopted for particular applications. For example, in the course of analysing public budgets, it will often be impossible to identify the environmental share or the net cost when classifying transactions, hence criterion A might be used. When conducting surveys of environmental expenditure of corporations, criterion A alone is less useful and a combination with other criteria might be used. This explains the introduction of criteria C and D as variants of criterion A.

5.32 Expenditures, activities and actions that are intended to improve environmental protection as well as serve another purpose cover investment in new technologies which incorporate environmental improvements and integrated investment programmes by public bodies. In such cases, separate information on the environmental component is generally neither available nor easily estimated. The extra-cost criterion (criterion B) is most useful for such actions. It cannot be used alone but only in combination with other variants.

5.33 Both the extra-cost criterion and the net-cost criterion (criterion C) exclude from environmental protection those measures that are undertaken for environmental protection reasons but result in net savings. Examples are energy saving or increases in productivity that are higher than direct gross costs. A particular case concerns in-house (ancillary) activities that are used instead of the purchase of marketed environmental protection services. For example, there could be net savings because of reduced waste treatment bills resulting from the starting of an own account waste treatment activity but in that case the costs of ancillary activity would have to be counted in place of the previously purchased services.

5.34 Criterion C also excludes sales of by-products of environmental protection activities. Valuable information might therefore be lost using this criterion. Use of the net-cost criterion is best restricted to identifying expenditure associated with environmentally protective technologies, processes and products.

5.35 The classification suggested for organising environmental protection activities is the Classification of Environmental Protection Activities and Expenditure (CEPA). The classification also applies to expenditure and products. Within the CEPA, environmental protection activities are first classified by environmental domain (air, waste, nature protection etc.) and then by type of measure (prevention reduction etc.). The main one-digit headings of CEPA are listed in Table 5.2; the detailed classification, as mentioned above, is given in annex V.

5.36 Experience has shown that basic data do not allow a full classification of activities and transactions below the level of detail suggested above owing to identification and separation problems. Therefore, the CEPA may be adapted for national purposes (for example, concentrating on soil erosion and salinity prevention activities).

Table 5.2. Classification of Environmental Protection Activities and Expenditure (CEPA)

1.	Protection of ambient air and climate
2.	Wastewater management
3.	Waste management
4.	Protection and remediation of soil, groundwater and surface water
5.	Noise and vibration abatement
6.	Protection of biodiversity and landscape
7.	Protection against radiation
8.	Research and development
9.	Other environmental protection activities
9.1	General environmental administration and management
9.2	Education, training and information
9.3	Activities leading to indivisible expenditure
9.4	Activities not elsewhere specified

Source: Annex V.

Natural resource management and exploitation activities

5.37 Natural resource management and exploitation activities cover the natural resources in the SEEA classification of assets (mineral and energy resources including subsoil deposits, soil, biological resources such as wild flora and fauna, and water resources (both marine and fresh water) as well as land and ecosystems). Wastewater management, and the protection of flora, fauna and ecosystems, are covered under environmental protection. As yet, there is no international classification of such activities. Work to identify relevant activities is ongoing.

5.38 Work on accounts for natural resource management may often depend on issues specific to a given country, for example, water shortage or forest management. Sometimes, the concern may be specifically directed at knowing whether the resource in question is being managed sustainably or not or may even be confined to only those activities that result in sustainable management.

5.39 ***Management activities*** include research into management of natural resources, monitoring, control and surveillance, data collection and statistics, and costs of the natural resource management authorities at various levels as well as temporary costs for facilitating structural adjustments of sectors concerned. Activities and transactions specifically for environmental protection, for example, management of protected forests, are not included (they are included under environmental protection expenditure activities where the primary purpose is the protection of the environment, as mentioned above). Similarly, qualitative protection activities of natural resources, for example, activities for biodiversity and landscape protection, or activities aimed at preserving certain functions or the quality of the natural environment (air, water, soil and groundwater), are also included under environmental protection.

5.40 Management activities may also result in associated secondary environmental benefits such as protection and restoration of wildlife and natural habitats.

5.41 ***Exploitation activities*** include abstraction, harvesting and extraction of natural assets including exploration and development. These accounts typically correspond to the standard economic accounts for various natural resource-related industries such as fisheries, forestry, mining and water supply. They complement the asset accounts described in chapters VII and VIII.

5.42 Natural resources can be depleted where they are turned into products, for example, oil and petrol, and they can also deteriorate in quality in cases where the asset is used in production processes or services, as may happen, for example, in the case of water. However, activities concerned with the transformation of natural resources into other products, including upstream and downstream activities, are not covered in this chapter.

5.43 Table 5.3 gives a more detailed description of what is included in the natural resource management and exploitation account for each resource and for each of the two main categories, management and exploitation of resources. Illustrative examples of the sorts of activities included follow. As noted above, it may be helpful to make a distinction between sustainable and non-sustainable management activities.

Table 5.3. Natural resource management and exploitation activities

Resources	Management	Exploitation
Subsoil assets	Administration of permits, planning supervision, research, regulation	Exploration and extraction
Inland waters	Administration of waterways and water bodies, supervision, research, elaboration of plans and legislation, water police	Exploration, extraction, treatment, distribution
Forest resources	National forest inventories, research for pest control, regulation	Silvicultural activities including harvesting and reforestation
Wild flora and fauna	Supervision and control of fishing fleets, assessment of stocks, administration of quotas and licences, research, regulation	Harvesting, fishing, hunting

Inland water mobilization

5.44 Mobilization covers all activities aimed at abstraction, treatment and distribution of water resources for their various uses. The following may be usefully distinguished:

(a) ***Drinking water supply***: Capital outlays for water abstraction (protection of abstraction perimeters, pumping stations etc.), processing of drinking water, pressure build-up, storage and distribution, expenditure for major maintenance. Operating expenses such as operating cost of production facilities, energy, purchase of treatment and distribution products, metering, billing and so on;

(b) ***Irrigation***: All mobilization activities corresponding to agricultural and animal breeding uses; groundwater abstraction, construction of dams, catchments for surface flows etc., including the operation of irrigation systems;

(c) ***Industrial water mobilization***: All mobilization activities corresponding to industrial uses of water; uses for cooling of power plants and industrial installations are included.

5.45 It would also be useful to distinguish between services provided by the water industry and services provided for businesses' own use.

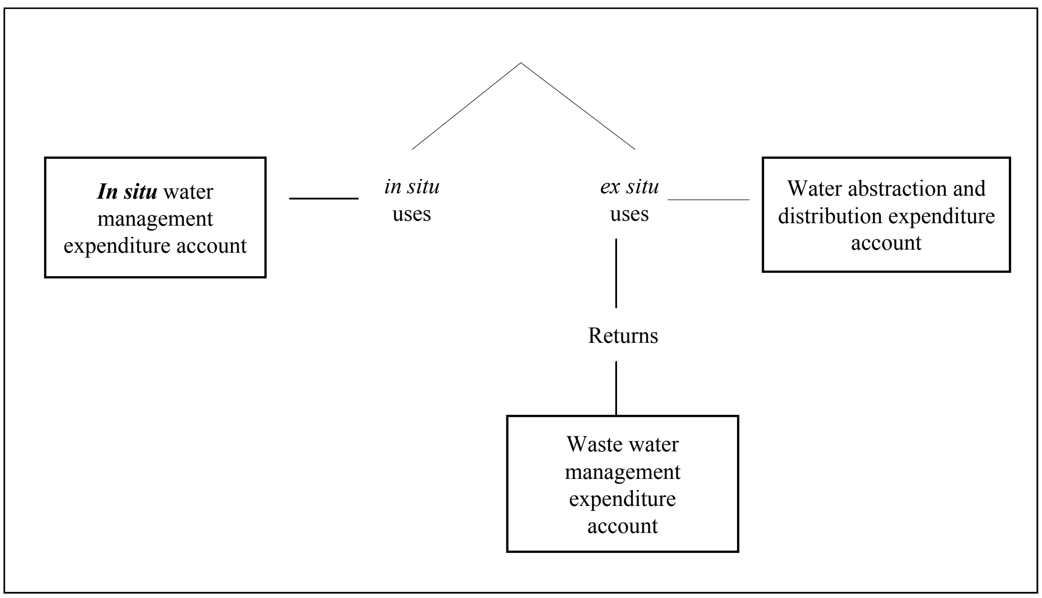
Management of water bodies

5.46 Management of water bodies may include activities involved in the transit of water from its "natural" status to that of "controlled" water status, reinforcing river banks, construction and maintenance of waterways, water engineering and dams. Dams for the production of electricity are not included. Recharging activities may consist of land improvement, and development of vegetal cover in order to increase water infiltration and recharge groundwater bodies. Insofar as they are not accounted for in protection of soil against erosion, corresponding transactions have to be recorded in the inland water management account.

Accounts for water: the experience of France

5.47 As a part of a complete system of water accounts, which include physical accounts for water quantity and quality, the Institut Français de l'Environnement (IFEN) has developed a set of monetary accounts for water. There are three main monetary accounts for water as shown in Figure 5.1.

Figure 5.1. Schematic diagram of French water accounts



5.48 The wastewater management expenditure account is a typical environmental protection expenditure account which describes the national expenditure for wastewater collection and treatment according to the methodology of the European System for the Collection of Economic Information on the Environment (better known by its French acronym, SERIEE) using the appropriate CEPA group.

5.49 The abstraction and distribution of water expenditure account covers expenditure for ex situ uses of water, drinkable water, industrial uses, including cooling, and irrigation. Conceptually, it covers expenditure for recycling and water saving, although data are rather scarce. This account shows the use of the water resource.

5.50 Finally, there is an account, still under development, that concentrates on the management of water in situ. It covers all expenditure the purpose of which is to maintain the in situ functions of the hydrological system (maintenance of minimal flows, restoration of rivers, increase of infiltration etc.).

5.51 IFEN has also developed a "prevention of natural hazards" expenditure account which includes flood prevention measures and a "protection of landscape and biodiversity" expenditure account. The latter pays particular attention to identifying overlap among the various accounts and so includes, for example, actions for the protection of freshwater fish.

5.52 Paying attention to overlapping areas is particularly important in the context of the establishment of a consolidated monetary water account, which will also cover all water-related expenditure that cannot be distributed to the sub-accounts for general administration, coastal waters and so on. Such a set of interrelated accounts can be useful with respect to responding to a variety of environmental protection and resource management questions. For example, the increased cost of water supply may be related to water pollution and land-use changes as described, separately, in chapters III and VIII.

Forest management

5.53 Management of forests includes expansion (afforestation) of wooded areas including net acquisitions of land for afforestation, their development for recreational use, inventories and assessment of forest resources, forest-related research, education, training and information activities, and forest-related administration and surveillance. Increasing use of wood for construction and furniture, or use of woody biomass as fuel etc., may be considered beneficial for the environment, as it substitutes products based on renewable resources for products based on non-renewable resources (plastics, concrete, fossil fuels etc.) and increases the net fixation of carbon.

5.54 Public financing may consist of transfers to producers for afforestation or maintenance of wooded areas, or expenditure by general government units engaged in other non-market activities (management, control, regulation of forest and forestry). Because of its importance, it may be desirable to establish a Forest Resource Management Account to record separately the transfers intended to pay for forest resource management expenditure as well as collective consumption of general government. The development and maintenance of wooded areas may benefit from other incentives in addition to subsidies, investment grants and other transfers. For example, specific reductions in taxes on forest assets, reductions in interest rates etc. may be intended to promote forest development objectives.

Fisheries management

5.55 Management of fisheries includes expenditures for fisheries management purposes, monitoring, control and surveillance, data collection, expenditure of the local, regional and national fisheries management authorities (such as fisheries management bodies), temporary costs for facilitating structural adjustments of the fisheries sector (for example vessel buy-back programmes, retraining) and research.

Environmentally beneficial activities

5.56 Although environmentally beneficial activities may be primarily undertaken for economic reasons and though the primary purpose is not the protection of the environment, they may nonetheless yield substantial environmental benefits. Examples are investment in energy or material saving equipment such as insulation and heat recovery, activities aimed at saving water such as investments in irrigation systems, industrial or household facilities to reduce water consumption, or recycle water, and the use of products adapted for lower water consumption (such as specially adapted washing machines).

5.57 As noted above, this is one of the newer areas for statistical examination but the importance of including it can be seen from a consideration of waste processing.

5.58 In the ISIC, Rev.3 (United Nations, 1990), recycling (division 37) is a class described as processing of (metal and non-metal) waste and scrap and of metal and non-metal articles into a form that is readily transformed into new raw materials. In-house waste minimization and in-house recycling and reprocessing are naturally included under environmental protection (waste management), often on the basis of the "net-cost criterion". However, the production of recycled goods, while not in itself an action to protect the environment, does have beneficial effects as it generates "secondary raw materials". Table 5.4 gives an interesting example of the amount of material input into recycling and the amount of recycled material coming out of the industry.

5.59 In practice, a clear separation of environmentally motivated and financially motivated measures is not always easy to achieve and much will depend on the primary data collected in specific surveys (see criteria B and C above).

Table 5.4. Recycling industries (ISIC 37), 1997: an example from the Netherlands

Input of waste and scrap and output of secondary raw materials, in millions of Netherlands guilders

Input (waste and residuals)	Paid to disposer	Received from disposer	**Output (secondary raw materials)**	Sales
Photographic waste	34	19	Crushed glass	60
Glass	38	12	Granulate, mix from plastics	200
Cable waste	18	4	Granulate, mix of stone, concrete	100
Plastics	75	13	Ferrous metals	223
Metals	195	5	Non-ferrous and precious metals	134
Construction and demolition waste [a]	8	169	Other [b]	15
Other [c]	25	83	Final products	27
Total	**393**	**305**		**759**

Source: Statistics Netherlands, production statistics.

[a] Including grit from drilling activities, slag and fly ash, and asphalt.

[b] Including granulate mix from rubber, and metal mix from electronics waste.

[c] Including waste rubber, waste from dismantling computers and other electronics, and waste paper.

Minimization of natural hazards

5.60 Expenditures and activities aiming at the minimization of natural hazards and of their impacts can be tabulated in the same way as environmental protection expenditure, although little country experience is available so far (except from France, in water-related example presented above). Such accounts may provide useful indicators of the effects of alterations of landscapes and water systems or global warming. It may, however, be difficult to determine to what extent natural hazards are caused by such human intervention. Countries will have different priorities and the accounts may include the following natural hazards:

(a) Forest fires;

(b) Floods;

(c) Avalanches;

(d) Landslides;

(e) Storms;

(f) Droughts;

(g) Earthquakes;

(h) Volcanic eruptions.

5.61 The nature of activities will differ according to the phenomenon covered and may include research, observation and measurement networks, surveillance, administration of hazard warning systems, provisions for fighting the effects of floods or forest fires (equipment etc.), provisions for the evacuation of the population, structures to prevent hazards (for example, fire barriers in forests, avalanche prevention barriers, dams to slow down water flows, and renaturalization of river banks and other landscapes).

5.62 Initially, only government expenditure may be covered. Government transfers or tax allowance records may also provide an indication of expenditure undertaken by corporations or households. Private entities could be surveyed.

5.63 The account could conceivably be extended to cover the costs of clean-up and remediation after the events so as to arrive at estimates of the economic damages caused by natural hazards and their evolution over time. Data from insurance companies and from government budgets could be a useful starting point.

2. Environmental protection activities

5.64 So far, most practical experience has been in the area of environmental protection. The present section and the next are therefore confined to this (large) subset of environmental activities. The objective in this section is to determine which units are actively involved in the production of environmental protection activities and what their products are. The next section considers which units purchase the products and which units finance the purchases.

5.65 Referring back to Table 5.1 again, we can see, for any class of environmental purpose, that there are environmental industries involved in production for that purpose but, also, that there may be some activities undertaken by industries that are non-environmental in character and some environmental activities undertaken by non-environmental industries.

5.66 For any producer, there must be a principal activity. For a market producer, this is the activity that produces most of the revenue (strictly speaking, most of the value added) for the enterprise. For non-market producers, the principal activity is the one that accounts for most of the costs of production. The identification of the principal activity is the basis on which the producer is allocated to one of the headings in an industrial classification. In addition to carrying out a principal activity, a producer, whether market or non-market, may produce smaller quantities of other products. If these are destined for use by other units, they are referred to as secondary production. Even when such subsidiary activity is retained by the enterprise and recorded as capital formation, it is also recorded as secondary production.

5.67 Products other than capital formation that are retained for use within the same unit are referred to as ancillary. In the SNA, ancillary activities are not identified in terms of output. This chapter discusses why it is desirable that they be so identified in the context of a satellite account for environmental protection.

5.68 Table 5.5 indicates the nature of principal, secondary and ancillary activities within the cell of Table 5.1 which presents output by industries classified by purpose. To this, we add another categorization: principal and secondary activities are referred to as external; ancillary activity, as internal.

Table 5.5. Principal, secondary and ancillary activities

		Industries	
		Environmental	Other
Purposes	Environmental	Principal production for environmental purposes. Secondary production for environmental purposes. Ancillary production for environmental purposes.	Secondary production for environmental purposes. Ancillary production for environmental purposes.
	Other	Secondary production for non-environmental purposes. Ancillary production for non-environmental purposes.	Principal production for non-environmental purposes. Secondary production for non-environmental purposes. Ancillary production for non-environmental purposes.

External activities

5.69 In principle, external environmental protection activities are easy to identify, since they result in an output that is separately identified in standard national accounts. This is true not only for products intended for sale to another unit but also for own-account capital formation, since it is recorded in the same way as any other capital formation in the SNA. The relevant activities can be determined by reference to the ISIC classification (see annex VII for descriptions of the categories and the codes). The main external environmental protection activity is "sewage, and refuse disposal, sanitation and similar activities" (ISIC 90). Other environmental protection activities may be found in ISIC 37 (recycling), 45 (construction), 51 (for example, wholesaling of waste materials and scrap including sorting), 73 (research and development), 75 (general administration) etc. These may be carried out as secondary as well as principal activities.

Separating out secondary activities

5.70 Ideally, when an enterprise or operating unit producing goods and services has a principal activity and secondary activities, for reporting purposes it should be subdivided and separate establishments created for each of the secondary products. The objective is to align reporting units as far as possible with a single product. In this way, the inputs of the unit relate to a single production process and aggregation of units matches the activity classification as closely as possible. This is a standard SNA recommendation but it is especially important in the present case, since many environmental protection activities are carried out as secondary activities.

5.71 However, the information system of the operating unit must be capable of calculating the value of production, intermediate consumption, compensation of employees, operating surplus, employment and gross fixed capital formation for each resulting establishment, and this is often not possible. For example, public bodies that often carry out environmental protection activities as part (but not a major part) of their responsibilities are usually unable to separately identify this sort of information. This may be the case for wastewater management and waste management and is very likely to be the case for other activities such as biodiversity and landscape protection. Under these circumstances, the corresponding output is often difficult to identify. Expenditure classified according to the Classifications of the Functions of Government (COFOG) (see United Nations (2000)) might be used to make estimates. If information is not readily available, either through the standard national accounts or through COFOG, direct analyses of public budgets might provide the primary data needed to describe environmental activities and their output.

5.72 Estimates should be attempted on a case-by-case basis, concentrating on the activities that are likely to be most significant, and using whatever information happens to be available. For example, if purchases of environmental clean-up services such as soil decontamination by government or property developers can be identified, the corresponding output can be estimated. If information is available for the production account of a unit carrying out a similar activity, it may be possible to make an approximate separation of the costs of the secondary activity on this basis.

5.73 Specialist production of environmental protection is taken to be that produced as either a principal activity or a secondary activity that can be separated out into a separate account as if it were a distinct establishment.

Identifying ancillary activities

5.74 All enterprises and establishments undertake some ancillary activities carried out by enterprises' own employees. These activities may cover only the simple overhead activities of keeping the accounts or they may be more extensive activities, covering staff training, in-house repairs and maintenance for buildings or vehicles, or activities falling under the definition of environmental protection. Examples are in-house waste or wastewater collection and treatment, the use of air scrubbers in power plants and the activities of environmental management units within enterprises.

5.75 Although the SNA recommends that the costs associated with secondary activities should, as far as possible, be separated from those for the principal activity, ancillary activities are not separately recorded and identified. The costs associated with these activities are merged without discrimination with other internal costs. In a satellite account, such as the one for environmental protection that is being considered here, it is important to identify and account for ancillary activities in a manner similar to the identification of secondary activities. The objective is to set up a production account for the activity in question by identifying all the costs, including labour input and the consumption of fixed capital related to the activity. The value of the ancillary output is then set equal to the costs incurred and is treated as intermediate consumption in much the same way as an external purchase of services by the establishment. Box 5.1 gives a simple example of how this is done.

5.76 Changing the recording of ancillary activities does not change any of the macroeconomic aggregates in the national accounts. The level of output increases but that of intermediate consumption rises by an equivalent amount so the balancing item, value added, is unaffected. However, the composition of both output and intermediate composition changes and all environmental protection activity is treated in the same manner whether it is internal or external.

Box 5.1. Example of "externalizing" ancillary activity

Suppose a firm purchases goods and services to the value of 1,000 to manufacture its output which it sells for 1,800. The cost of the compensation of employees is 500, consumption of fixed capital is 100 and operating surplus is 200. The standard production and generation of income account entries then appear as follows.

Uses		Resources	
Intermediate consumption	1 000	Output	1 800
Value added	*800*		
Compensation of employees	500		
Consumption of fixed capital	100		
Net operating surplus	200		

Now suppose that out of the 1,000 spent on intermediate consumption, 100 is for cleaning materials, 40 of the compensation of employees covers cleaners, and 5 of the consumption of fixed capital relates to cleaning equipment. By subdividing the output to show cleaning and other output separately, the accounts could be restructured as follows.

Uses	Excluding cleaning	Cleaning	Total	Resources	
Intermediate consumption				Output	
Excluding cleaning	900	100		- cleaning	145
Cleaning	145			- other	1 800
Total	1 045	100	1 145	- Total	1 945
Value added	*755*	*45*	*800*		
Compensation of employees	460	40	500		
Consumption of fixed capital	95	5	100		
Net operating surplus	200	0	200		

The total cost of the cleaning services is 145 (by convention, no ancillary service generates net operating surplus). Both the value of output and the total intermediate consumption of the establishment increase by 145 but the value added and all the entries of the generation of income account are unchanged in total. At the economy-wide level, GDP and other macro-aggregates are unaltered. However, it is now possible to treat the cleaning activity exactly as if a separate company had been formed with these costs. This process of identifying and separating the costs of ancillary services is called "externalizing" the activity.

5.77 Measuring ancillary output, although straightforward in concept, does present practical difficulties. Standard statistical surveys for enterprises or establishments generally do not separately identify internal (or own-account) expenditure on environmental protection. Special environmental expenditure surveys must be conducted in order to obtain this information. Expenditure on clean technologies such as capital equipment to reduce emissions or waste discharges in the course of production is difficult to identify. Consumption of fixed capital cannot be identified easily in surveys and must be calculated, usually by using the perpetual inventory method which requires long time-series of capital formation.

5.78 Even when ancillary activity can be separately identified, it continues to be treated as secondary activity within the unit where it takes place and not as a separate establishment. Non-specialist production of environmental goods and services thus consists of ancillary activity plus any (true) secondary activity that cannot be separated into a separate establishment.

3. Environmental products

5.79 The previous section described the activities that are regarded as characteristic of the environmental activity we wish to measure in the satellite account. In this section, we consider the products that are characteristic of the same activities. Products cover both goods and services and it is the environmental services such as those directly contributing to environmental protection that are the most obvious characteristic products. However, there are a number of goods that must be considered as well. Some of these are sometimes described as "connected" products. These are products that, though not made by the industries characteristic of environmental protection activity, are (virtually) always used in connection with the implementation of the activity. The brooms used by road sweepers are a classic example. Although it is the road sweeping that is the activity characteristic of environmental protection, the broom is an indispensable tool for the road sweeper and is therefore treated as an environmentally "connected" product. In terms of Table 5.1, connected products fall within the column for environmental products and within the row for other industries.

5.80 In the same location, we may also find "adapted" products. These are products that have been specially modified to be more environmentally friendly and whose use is therefore beneficial for environmental protection.

5.81 The full set of products characteristic for the environment therefore comprises those environmental services that correspond exactly to the characteristic activity and those goods and services that are environmentally connected or adapted. They fall within the first row and column of Table 5.1.

Environmental protection services

5.82 Environmental protection services are the products of environmental protection activities. These were discussed above and the products, like the activities, can be classified according to the CEPA. A distinction is made between those that are treated as market and those that are treated as non-market. Market services are those that are sold either by government or by private enterprises at a price that covers all or most of the costs of production. Non-market services are those that are produced by government[16] and provided free or at insignificant prices to the public at large or to individual households. Ancillary services fall between these two categories.

Other environmental products

5.83 There are two broad categories of other environmental products. The first category corresponds to products that are used directly and solely for environmental protection (for example, septic tanks, filters, waste bags): these are referred to as connected products. The second category, comprising what are referred to as adapted products, corresponds to products that are cleaner (and therefore more environmentally friendly) when used or disposed of. These products are sometimes also called (environmentally) cleaner products. The inclusion of these products is needed to provide a complete picture of environmental protection and to ensure international comparability. If spending on clean products is ignored, then, for example, countries that are densely populated and have comprehensive sewage collection networks will wrongly appear to have greater environmental expenditures compared with more sparsely populated countries where septic tanks predominate.

5.84 The environmental cost of a connected product is simply the cost of the product. Estimates of the cost of adapted products are made in a manner similar to the method of costing integrated technologies, that is, the extra-cost criterion is used to identify the relevant expenditure. The methodological difficulties are thus similar and involve comparison with the corresponding "dirty"

[16] In theory, such non-market services could also be provided by non-profit institutions serving households (NPISHs) but this possibility is ignored in the discussion and tables that follow.

product. For example, unleaded gasoline or desulphurized fuels may be more expensive to produce and these extra costs of production are recorded here as environmental protection expenditure.

5.85 A great number of environmental products may exist. However, experience in EU countries suggests that only very few are quantitatively important and involve significant extra expenditure. (A significant amount of expenditure on connected and adapted products is incurred by households.) For many such products, it is found that no extra costs exist. For practical purposes, a short list of environmental products has been developed for use by EU countries which may form a basis for use by other countries, adjusted as necessary to the specific needs and circumstances of those countries. This list is set out in Box 5.2.

Box 5.2 EU list of connected and adapted environmental protection products

Mandatory inclusion

- Septic tanks.
- Maintenance services and other products for septic tanks.
- Catalytic converters for vehicles.
- Desulphurized fuels (extra costs only).

Recommended for inclusion

- A more complete set of measures related to transport vehicles, based on the cost of compliance with environmental regulations, including measurement services of exhaust gases of vehicles, measures to adapt private cars (other than using catalytic converters) and measures to adapt trucks, buses and aeroplanes.
- Trash bags, bins, rubbish containers, compost containers. This item is dependent on the organization of waste collection in a country, based, for example, on whether or not wheeled rubbish containers are provided by the local authorities or on whether rubbish containers are owned by local authorities or must be purchased by households. Publicly accessible containers for collecting material for recycling are typically owned by specialist waste collectors and therefore already covered via these producers' investments and capital stocks.

Possible inclusion

- Services for the measurement and supervision of exhaust gases of heating systems.
- Exhaust pipes of vehicles.
- Soundproof windows (extra costs only).

Source: Eurostat (2002).

4. The "environment industry"

5.86 The manufacturers of all these environmental products are collectively referred to (albeit not quite exactly and initially confusingly) as an "industry" cutting across conventional industrial classifications.

5.87 The ***environmental goods and services industry*** (often referred to as the ***"environment industry"*** for short) consists of activities that produce goods and services to measure, prevent, limit, minimize or correct environmental damage to water, air and soil, as well as problems related to waste, noise and ecosystems, including cleaner technologies, and products and services that reduce environmental risk and minimize pollution and resource use, as well as activities related to resource management, resource exploitation and natural hazards. The environment industry supplies the products for environmentally related expenditures.

5.88 Because the environment industry cuts across standard industrial classifications, its identification requires specific surveys and analysis. OECD and Eurostat (1999) have jointly published a manual entitled *The Environmental Goods and Services Industry: Manual for Data Collection and Analysis* which discusses the definition and classification of the goods and services of interest and suggests procedures for data collection and analysis.

5.89 The main policy-related interest concerns the impact on economic activity, trade and employment due to environmental protection measures. The principles of satellite accounting can be invoked to address such issues, including the impact on employment.

Definition and classification of the environment industry

5.90 The activities covered by the "environment industry" are grouped together according to three main groups of activities: pollution management, cleaner technologies and products, and resource management.

(A) The **pollution management group** comprises goods and services that are clearly supplied for an environmental purpose, have a significant impact in reducing polluting emissions and are easily identifiable statistically. In practice, this covers environmental protection services and those clean products used specifically for environmental purposes, for example, as fixed capital formation for producers of environmental protection services.

(B) The **cleaner technologies and products group** comprises goods and services that reduce or eliminate negative environmental impacts, but that are often supplied for other than environmental purposes and for that statistical assessment remains disputed, difficult or expensive.

(C) The **resource management group** comprises goods and services that are peculiar to natural resource management. Although environmental protection is excluded from the coverage of resource management, inevitably some products that are associated with environmental protection may be included, although their prime purpose is not environmental protection (for example, those used for energy saving and management, renewable energy etc.). The collection of data for this group is still in the developmental stage.

5.91 Annex VIII, which sets out the full classification of the environment industry, covers in detail the production of equipment and specific materials, the provision of services, and construction and installation as they relate to each of the three main activity groups of the environment industry.

Relation between environmental purpose and environment industry categories

5.92 With respect to the environmental purposes identified in section B, environment industry activity groups A (pollution management) and B (cleaner technologies and products) have a direct correspondence with activities with an environmental protection purpose; the resource management activity group C corresponds to activities with a resource management and exploitation purpose. Note, however, that this correspondence is not exact. For example, activities related to nature protection come under environmental protection activities in CEPA and under the resource management group in the environment industry account. This reflects differences in the underlying data sets for the different classifications.

5.93 Environmentally beneficial activities and the minimization of natural hazards are not as well developed as the other environmental protection activities noted in section B. It is useful, however, to note the relevance of these activities for a comprehensive coverage of environmental activities even if the data do not permit implementation at this stage.

5.94 Within the activity groups of the environment industry, there is a further breakdown of equipment and materials, services and construction and installation. Within each of these types of product, there are distinctions made by purpose using a breakdown that follows that of CEPA as closely as possible, given the constraints of the data sources.

C. Environmental protection expenditure accounts (EPEA)

1. Supply and use tables for environmental protection

5.95 Having determined the coverage of environmental protection activities and products, the next stage is to compile production and generation of income accounts for these activities and supply and use tables for these products. The present section examines how the production of those goods and services is organized and marketed. This requires activities, products and expenditure categories to be considered separately. This section concentrates on steps taken to deal with residuals and does not explicitly consider protection of the environment through the means of water and energy conservation or the effects of recycling. An overview of the categories to be described is given in Box 5.3.

Box 5.3. Environmental protection activities, products and expenditures

Categories of environmental protection activities

External activities; activities whose products are for use by other units
- Principal activities; identified based on specific ISIC/NAICS [a] codes (specialized producers)
- Secondary activities; activities not separately identified with reference to ISIC/NAICS codes

Internal or ancillary activities; activities undertaken for own use

Categories of environmental protection products

Environmental protection services
- Market (for example, waste collection services sold)
- Ancillary services (for example, ancillary air or noise protection)
- Non-market (for example, government administration or surveillance)

Other environmental protection products
- Solely used for environmental protection (for example, septic tanks, trash bins)
- Principally used for other reasons but cleaner when used (for example, desulphurized fuels)

Categories of expenditure on environmental protection:

Current expenditure (for example, operating expenditure, purchase of environmental protection products)
Capital expenditure (for example, investment expenditure for end-of-pipe equipment)

[a] International Standard Industrial Classification of All Economic Activities/North American Industry Classification System

Categories of expenditure on environmental protection

5.96 Separating ongoing or current costs from one-time or capital costs is necessary for the supply and use tables. It is also of intrinsic interest to show how far the burden of environmental protection is ongoing rather than one-time and to what extent there may be a trade-off between the two types of expenditure. Different classifications can be applied to both types of expenditure. Here, it is assumed the greatest interest lies in the type of environmental activity involved in current expenditure and the type of technology used for capital expenditure. If the data sources were sufficiently detailed, further classifications and cross-classifications would also be possible.

Current expenditure

5.97 Current expenditure by enterprises includes internal operational spending on environmental protection activities including, for example, wages and salaries of people involved with the operation of pollution control equipment and environmental management, leasing payments for environmental equipment, and materials such as air filters and scrubbers. External expenditure, inter alia, on waste disposal by specialist contractors, wastewater treatment, regulatory charges to environmental agencies and so on are also treated as current expenditure whether made by enterprises, government or households.

Capital expenditure

5.98 Two types of capital expenditure can be distinguished:

(a) Expenditure on end-of-pipe technologies used to treat, handle or dispose of emissions and wastes from production. This type of spending is normally easily identified even within the context of ancillary activity because it is usually directed towards an “add on” facility which removes, transforms or reduces emissions and discharges at the end of the production process;

(b) Expenditure on “integrated investments”, also called cleaner technologies. These are new or modified production facilities designed so as to ensure that environmental protection is an integral part of the production process, thereby reducing or eliminating emissions and discharges and thus the need for end-of-pipe equipment.

5.99 Integrated investments may result from the modification of existing equipment for the explicit purpose of reducing the output of pollutants, or from the purchase of new equipment whose purpose is both industrial and for pollution control. In the first case, expenditure can be estimated from the cost of the modification of existing equipment. In the second, the extra cost due to pollution control has to be estimated - that is, the cost of “non-polluting or less-polluting” equipment is compared with that of “polluting or more-polluting” reference equipment.

5.100 Such estimates are difficult to make when reference equipment no longer exists or when new equipment presents other advantages in addition to its beneficial effects on the environment. These may include savings on or substitution of raw materials, higher productivity and so on which cannot be isolated in terms of cost. The difficulty arises because the steady integration of environmental standards into equipment and processes means that eventually it becomes impossible to identify a part of the expenditure as environmental. Given the different speeds at which new environmental standards are incorporated into different types of equipment and in different countries, comparison of long time-series across industries and countries becomes difficult. However, a misleading picture is obtained if the cost of significant capital equipment is ignored.

The supply table

5.101 The first step in compiling a supply table is to establish which industries make which products. Such a table will show the extent of secondary production by the environment industry and also the extent to which environmental goods and services appear as secondary products of other industries.

5.102 Environmental protection services are usually supplied by domestic units. However, imports and exports of some environment industry products such as environmental protection equipment may be significant.

5.103 Output of market services is valued at basic prices, that is, it records the amount received by the producer excluding any taxes on products. Non-market output is valued at the cost of production (because non-market producers do not make any net operating surplus) and also excludes taxes on products.

5.104 In order to compile total supply, it is necessary to add imports to domestic output and also to include taxes on products and imports as well as trade margins and any transport costs that the purchaser must pay for delivery of the products. The total of these items gives a value of total supply at purchasers' prices. For some clean products, however, this basis of valuation may be too high, since only the difference between the cost of a clean product and a "dirty" equivalent should be recorded as environmental protection expenditure. In making an estimate of the difference between the cost of a clean product and that of a corresponding "dirty" product, attention should be paid to the impact, if any, of different levels of tax or subsidy applying to the different types of product.

The use table

5.105 For each type of product shown in the supply table, it is necessary to determine what sort of use it satisfies. Use of environmental protection services (for example, by production units that purchase waste treatment services) may be classified as "intermediate consumption" in standard national accounts terms, as "fixed capital" by enterprises or general government or as "final consumption" by households or general government.

5.106 The non-market services provided by government may be classified as either collective or individual consumption. Individual consumption relates to those services that benefit individual households to the exclusion of others and, in principle, an allocation of benefit to the households concerned can be made. Collective consumption benefits the whole community and the extent to which one household avails itself of the service does not affect the amount available to others. Typical individual consumption services are collection of household refuse and wastewater collection and treatment. Road-sweeping is typical collective expenditure. However, it may often be that, for some individual expenditures, the sums involved are very small or there is no satisfactory basis for allocation to individual households. In these cases, such services remain under the general "protection of the environment" heading and are treated with other non-market environmental protection services as collective consumption.

5.107 Typically, the method used to estimate the expenditure associated with the use of clean products is based on physical information about market sizes (amount of desulphurized fuels used, number of newly registered cars equipped with a catalytic converter, number of newly constructed houses equipped with septic tanks etc.). These estimates are then valued by either the market price or by the extra cost due to environmental protection features in the case of environmentally friendly products. Extra costs will normally be difficult to survey so that expert assessment and technical knowledge may be used to estimate extra costs (for example, the extra costs of producing desulphurized fuels or of environmental adaptations of vehicles).

5.108 Expenditure for pollution management may be separated into equipment and specific materials on the one hand and construction and installation on the other. Equipment and materials are classified as either intermediate consumption or gross fixed capital formation of specialist and ancillary producers just as clean products are. Expenditure on construction and installation is treated as investment for environmental protection.

5.109 As indicated earlier, ancillary output should be separately identified and treated both as output in the supply table and as intermediate consumption in the use table. It is recorded in the supply and use tables by adding supplementary columns and rows corresponding to the ancillary activities and output. Alternative presentations are also possible. One option, which would facilitate comparisons with standard supply and use tables, is to add columns showing the current outlays corresponding to the ancillary activities for each industry; another option is to create a specific column aggregating together the current outlays for the ancillary activities of all industries.

Supplementary data

Value added

5.110 The value added of environmental protection activities represents the contribution made by these activities towards the income measure of GDP. It is the difference between the value of the output and the sum of all intermediate costs. The value added for all industries can be equated with the total final demand, but this is not true on an industry-by-industry basis.

Generation of income account entries

5.111 One reason to consider value added is to show how much of it covers compensation of employees (remuneration of labour), taxes on production (other than taxes on products), any subsidies on production and gross operating surplus. It is also useful to show numbers of employees (in terms of person-hours if at all possible, or full-time equivalents) as well as compensation of employees to demonstrate the role of environmental protection activities in the labour market.

Environmental protection capital stock accounts

5.112 Gross operating surplus should be separated into the element that shows how much capital formation has been used up in the period (consumption of fixed capital) and the net operating surplus. The calculation of consumption of fixed capital also involves estimates of the capital stock available to environmental protection activities. This is another sort of supplementary data that it is helpful to present with the combined supply and use table.

5.113 In order to calculate the consumption of fixed capital (sometimes referred to as depreciation) and to link expenditure data to physical flow accounts, capital stock accounts should be set up based on long time-series of investment. Capital stock accounts will often be created using the perpetual inventory method. Experience suggests that, if long time-series are not available, an initial estimate of the capital stock in place (and its age structure) can be based on a variety of primary data such as the following:

(a) Physical environmental data related to capital stock, for example, population served by sewerage networks, number, capacity and category of treatment of wastewater treatment plants, and number and capacity of waste incineration plants, power plants equipped with flue gas scrubbers etc.;

(b) Physical environmental data related to pollutant releases, produced, for example, by using the amount of waste for treatment as the basis for estimating the cost of treatment and the capital stock needed for treatment and collection, or using time series of air emissions together with data on energy use and output to assess the environmental protection measures undertaken;

(c) Legal and administrative information, for example, information arising from the coming into force of major environmental laws which may give an indication of past patterns of investment, or permit and supervision data;

(d) Data on environmental investment supported by government via investment grants or preferential loans, especially if long time-series are available;

(e) Engineering estimates and expert assessment;

(f) Data on operating expenditure as a basis of estimates of the capital stock in place.

5.114 The initial capital stock must be determined or estimated by categories of capital goods (vehicles, structures and machinery) and by age class. The normal national accounts assumption of the lifetime for these categories may then be applied (unless more specific information is available) to calculate the consumption of fixed capital.

5.115 Capital stock accounts also allow the operating expenditure related to the gross stock of capital in place to be estimated. For this, case studies and expert assessment may be used to estimate average ratios of operating expenditure to the stock of environmental capital, ideally by age of the equipment. For such estimates to be reliable, detailed breakdowns of the capital stock by environmental domain and by type of capital goods as well as detailed categories of operating expenditure (wages and salaries, energy, maintenance, etc.) are recommended. Detailed breakdowns also permit detailed price indices to be applied to each category.

The combined supply and use table

5.116 An illustrative example of a simplified supply and use framework for environmental protection services is given in Table 5.6. This follows the same scheme as used in chapter IV and shows the supply and use matrices together with the supplementary data. It allows all the data derived from the primary data sources to be fitted into the framework. Gaps may well remain between supply and use which can be filled by estimation. For example, the split of the use of marketed services between households and businesses can be estimated based on physical data and average prices.

Table 5.6. Combined supply and use table for environmental protection goods and services

Millions of currency units

	Government services	Specialist services	Ancillary services	Cleaner/connected products	Non-environmental protection goods and services	**Total**	Government producers of environment services	Specialist producers of environment services	Ancillary production of environment services	Producers of cleaner/connected products	Other producers	**Total intermediate consumption**	Government consumption	Household consumption	Capital formation	Exports	**Total**
Government services												**0**	1 800	1 320			**3 120**
Specialist services								1 500			3 400	**4 900**		1 650	100		**6 650**
Ancillary services											4 000	**4 000**					**4 000**
Cleaner/connected products								400			200	**600**		600			**1 200**
Non-environmental protection goods and services							2 000	1 100	1 000	300	*	*					*
Total							**2 000**	**3 000**	**1 000**	**300**	*	*	**1 800**	**3 570**			*
Government producers	3 000				0	**3 000**											
Specialist producers		6 500		0	0	**6 500**											
Ancillary production			4 000			**4 000**											
Producers of cleaner/connected products				1 000	0	**1 000**											
Other producers	0	0	0	0	*	*											
Total output																	
Compensation of employees							600	2 000	2 000	500	*	*					
Consumption of fixed capital							400	1 000	1 000	200	*	*					
Taxes on production less subsidies on production							0	0	0		*	*					
Net operating surplus							0	500	0		*	*					
Output at basic prices	**3 000**	**6 500**	**4 000**	**1 000**	*	*	**3 000**	**6 500**	**4 000**	**1 000**	*	*					
Imports				50	*	*											
Taxes and margins	120	150		150	*	*											
Output at purchasers' prices	**3 120**	**6 650**	**4 000**	**1 200**	*	*											
Gross fixed capital formation							1 100	1 000	2 500	1 500	*	*					
Capital stock							7 000	15 000	12 000	10 000	*	*					
Labour input							4 000	10 000	8 500	5 000	*	*					

Source: SEEAland data set.

Note: An asterisk (*) indicates a cell where there would, in principle, be large entries in a full supply and use table, but that are not relevant for the purpose of the present chapter; as these are non-environmental products and are not used for environmental protection.

5.117 While Table 5.6 gives a good overall view of the interaction between the elements of supply and use, it can be cumbersome to use when a reasonable degree of detail is introduced. For that reason, the EPEA are usually presented in a more compact manner, as exemplified in Table 5.7.

5.118 All producers of environmental protection goods and services are shown under one of three headings: government providers of environmental services, specialist providers and other non-specialist providers. Activities that are not related to environmental protection goods and services are not included. However, similar tables can be produced for cleaner and connected products, as shown in the last column of Table 5.7.

5.119 The difference in layout between the two tables is comparable with that between Tables 3.12 and 3.13. In Table 5.7, the supply table which can be read from the middle set of columns of Table 5.6 is presented in the same way. The use table which appears across the first set of rows in Table 5.6 is transposed and appears below the supply table in Table 5.7. In addition, supplementary information can be included below the use part of the table.

5.120 The layout of Table 5.7 can be used to provide a disaggregation of environmental protection activity, for example, by CEPA categories or for specific cleaner and connected products.

Table 5.7. Augmented supply and use table for environmental protection services

Millions of currency units

	Government producers	Specialist producers	Non-specialist producers	Total	Cleaner and connected products
Supply table					
Intermediate consumption	2 000	3 000	1 000	6 000	
Compensation of employees	600	2 000	2 000	4 600	
Consumption of fixed capital	400	1 000	1 000	2 400	
Taxes less subsidies on production				0	
Net operating surplus		500		500	
Output at basic prices	3 000	6 500	4 000	13 500	1 000
Imports				0	50
Total supply at basic prices	3 000	6 500	4 000	13 500	1 050
Taxes on products	120	150		270	100
Trade and transport margins				0	50
Total supply at purchasers' prices	3 120	6 650	4 000	13 770	1 200
Use table					
Intermediate consumption					
Government producers					
Specialists producers		1 500		1 500	400
Non-specialist producers: ancillary			4 000	4 000	
Non-specialist producers: other		3 400		3 400	200
Government consumption	1 800			1 800	
Household consumption	1 320	1 650		2 970	600
Capital formation		100		100	
Total use	3 120	6 650	4 000	13 770	1 200
Supplementary information					
Gross fixed capital formation	1 100	1 000	2 500	4 600	1 500
Stock of fixed capital	7 000	15 000	12 000	34 000	10 000
Labour input (thousands of hours worked)	4 000	10 000	8 500	22 500	5 000

Source: SEEAland data set.

2. National expenditure on environmental protection

Objective

5.121 The supply and use table shows the extent of environmental protection activity undertaken in the country and which units consume it. This is not necessarily the same as the total amount of national resources devoted to environmental protection. Later in the SNA sequence of accounts, beyond the supply and use tables, transfers are recorded and some of these may affect the level of spending on environmental protection. For example, if government subsidizes some environmental protection, then the extent of this subsidy will not be caught in a supply and use tables measured, as assumed above, in market (purchasers') prices. Further, in some cases, there may be funding received from abroad which reduces the need to finance the whole of environmental protection expenditure from national resources. This is so within EU where central funds may be made available for environmental protection expenditure and also within developing countries where international aid may be specifically targeted at environmental protection; and may also be the case when it is more beneficial for a country to provide funding to a neighbouring country to prevent pollution than to face the cost of domestic remediation.

5.122 The various elements that enter this national expenditure aggregate can be compared with the corresponding aggregate from national accounts. Final consumption on environmental protection may be compared with total final consumption; gross capital formation for environmental protection may be compared with the gross capital formation of the total economy.

5.123 However, national expenditure on environmental protection is not strictly comparable with GDP, as intermediate consumption is included in the first but not in the second of these aggregates. Such a comparison can be made based only on a number of usually quite realistic hypotheses. One is that the amount of environmental protection embodied in imports and that embodied in exports are approximately equal so that the pattern of imports and exports does not distort the comparison. Another is that all intermediate environmental protection expenditures are passed on to the customers by the enterprises making the expenditure, that is to say, if industries increase their intermediate consumption of environmental protection products, then they pass the whole of this cost on to their customers in the form of increased prices.

5.124 Some countries may record environmental protection flows in such a way as to introduce deviations from a strict comparability with central aggregates. Experience so far suggests that these deviations are negligible, so that national expenditure can in fact be fairly compared with GDP. It should be noted, however, that a calculation in constant prices poses much greater difficulties.

Measuring national expenditure on environmental protection

5.125 Table 5.8 shows how an aggregate for national expenditure on environmental protection can be derived.

5.126 For most economies, the largest part of environmental protection expenditure will be accounted for by the use of environmental protection services and cleaner and connected products. These correspond to the information in the supply and use table (Table 5.7) and are shown as items 1 and 2 in Table 5.8. These items are subdivided to show intermediate consumption (both ancillary and non-ancillary), final consumption and capital formation separately. Although exports of environmental protection products are possible, they are not recorded here, since they are not funded from within the national economy.

5.127 In order to avoid double counting, the intermediate consumption of environmental protection services by the producers of environmental protection services is not recorded in the tables. (The entries are thus shown as NR (non-recorded).) It is assumed that the costs of specialist producers are covered by the purchases made by the consumers of the products. The ancillary costs are covered in the inclusion of this item in intermediate consumption.

Table 5.8. National expenditure on environmental protection

Millions of currency units

	Specialist producers	Other producers	Consumers		Rest of the world	Total
			House-holds	General govern-ment		
1. Use of environmental protection services						
a. Intermediate consumption (non-ancillary production)	NR	3 400				3 400
b. Intermediate consumption (ancillary production)		4 000				4 000
c. Final consumption			2 970	1 800		4 770
d. Capital formation	NR	100				100
2. Use of cleaner and connected products						
a. Intermediate consumption	NR	200				200
b. Final consumption			600			600
c. Capital formation	NR					
3. Capital formation for environmental protection	2 100	2 500				4 600
4. Specific transfers not included in items 1 to 3						
a. Current	NR				300	300
b. Capital						
5. Total uses	2 100	10 200	3 570	1 800	300	17 970
6. Of which financed by the rest of the world				100		100
7. National expenditure for environmental protection	2 100	10 200	3 570	1 700	300	17 870

Source: SEEAland data set.

Note: NR = non-recorded.

5.128 Items 1d and 2c show the expenditure on environmental protection services and cleaner and connected products that are undertaken as capital formation by non-specialist producers. Capital formation in environmental protection services (item 1d) is environmental clean-up services that lead to improvement of land. Households and government undertake capital formation only in their capacity as producers so it is assumed that this one entry captures all capital formation by non-environmental producers. Capital expenditure on these items by specialist producers is not recorded separately because these items are already included in item 3, Capital formation for environmental protection.

5.129 In addition to capital expenditure on environmental protection services and cleaner and connected products, the table shows (item 3) capital expenditures by specialist and other producers on other items required for the production processes of environmental protection activities. These may not – and generally be will not – be environmental protection products themselves. For example, the item may include buildings and transport equipment. Nevertheless, these expenditures are necessary to maintain the national effort on environmental protection activity.

5.130 Item 4 comprises specific transfers not captured in items 1 to 3. The objective of this term is to capture any unrequited payments made by government or other units that represent expenditure on environmental protection but are not captured in items 1 to 3. They may cover consumer subsidies that are not captured in government final consumption, subsidies on production or investment grants; the first two types of payments are classified as current specific transfers and the third as a capital-specific transfer. The characteristic that qualifies specific transfers to be included under item 4 is either that they alter the price at which environmental protection products are acquired or that they have no counterpart at all in items 1 to 3 (for example, transfers to other countries as part of international cooperation). Not all transfers relating to environmental protection will be registered here. Only those transfers that affect the total level of expenditure are considered at this point. For example, a transfer from central to local government affects whichever of the two units bears the cost of the expenditure (a point that is investigated below) but not the level of the expenditure. Investment grants are not to be included in item 4 when the corresponding capital formation is already included in item 3.

5.131 One effect of this may be purely practical rather than theoretical. Suppose government makes a transfer to a non-governmental organization for environmental protection. In principle, the expenditure of this non-governmental organization should be included in item 4 and the transfer would not then need to be included in national expenditure. In practice, though, measuring all such units is difficult and if there is no record of the unit receiving the transfer in the basic data, the transfer without a recorded counterpart may be included to make good this omission.

5.132 Item 5, Total uses, is the sum of items 1 to 4. To this, adjustments must be made for inflows from and outflows to the rest of the world that affect the overall national effort on environmental protection expenditure, shown as item 6. These flows also can be subdivided into current and capital elements.

5.133 National expenditure on environmental protection (item 7 of Table 5.8) can thus be defined as

final and intermediate consumption of environmental protection products by resident units, other than those of the environmental protection producers themselves;

plus capital formation on environmental protection products;

plus gross capital formation on other products required for environmental protection activities;

plus (current and capital) specific transfers by residents units not captured in the items above;

plus (current and capital) financing provided by transfers to the rest of the world;

less financing by transfers received from the rest of the world.

5.134 It is also useful to show the total expenditure within the economy divided into current and capital expenditure. Capital expenditure comprises items 1d, 2c, 3 and 4b, that is, capital formation on environmental protection products, plus capital formation by specialist and other producers for environmental protection activities, plus specific transfers that are classed as capital. The remaining components of item 5 are treated as current expenditure. Based on the SEEAland data given in Table 5.8, current expenditure is 13,270 million currency units and capital expenditure is 4,700 million currency units. Financing provided to and received from the rest of the world can also be divided into current and capital elements to reach a division of national expenditure into current and capital elements.

3. Financing environmental protection

5.135 Table 5.9 shows expenditure as undertaken by different units. Again, this may not show who directly bears the cost because of the role of transfers in the system. In the compilation of Table 5.8, specific transfers where both counterpart entries were recorded in the basic data were ignored in order to avoid double counting. This information, however, provides a valuable insight regarding which unit is driving the decision to make the expenditure. For example, if an investment grant is not available, an enterprise may be much less likely to undertake the capital formation in environmental protection that the grant would cover. The enterprise has to be concerned neither about earning sufficient operating surplus to pay for the investment nor about borrowing to finance it.

5.136 It is therefore useful to amend the entries in Table 5.8 to show which units are directly responsible for the expenditures and which directly bear the costs of financing them. For both current-specific and capital-specific transfers related to environmental protection, the unit making the transfer has an increase in expenditure and the unit receiving the transfers has a reduction.

5.137 Many of the specific transfers will be of the nature of subsidies and investment grants where government is the payer of the transfers and it is industries or households that benefit. An example of a transfer benefiting households may be a grant to improve house insulation. If the grant is large and results in appreciation of the property value, then the transfer will be recorded as a capital transfer. If the grant is more modest and closer to funding for an immediate remedial problem, then it is more likely to be recorded as a current transfer.

5.138 Some specific transfers may flow in the other direction, from households and industries to government. Examples are earmarked environmental taxes such as landfill charges. In such a case, the payments are more akin to a fee for a service than a tax and the effects can be shown in the satellite account as funding of government expenditure on environmental protection by those paying the earmarked taxes. (Note that this is counter to SNA recording where all taxes, whether earmarked or not, simply go into government revenue from which all government expenditure is financed.)

5.139 Not all specific transfers will necessarily involve government as either payer or recipient. Both households and industries may make transfers to non-governmental organizations or charities concerned with environmental protection, for example, and it is possible to envisage transfers from industries to their employees to encourage certain forms of environmental protection, possibly on a one-time basis.

5.140 Making adjustments for these forms of transfers does not completely determine who ultimately bears the cost of environmental protection. Costs that initially fall to enterprises are eventually passed on to their customers. This applies to both intermediate consumption and the costs of new capital formation. All government expenditure is funded (at least in large part) by taxes and thus is ultimately borne by those paying the taxes.

5.141 It is possible to estimate an intermediate level of financing with discretion over how far the indirect financing effects are traced. The treatment of earmarked taxes described above is one example. This could be extended to other "green" taxes designed to encourage more environmentally friendly behaviour.

5.142 Table 5.9 gives an example of how Table 5.8 may be amended to show the initial direct financing of environmental protection expenditure. National expenditure is derived as the sum of expenditure by government, corporations and households.

5.143 The entries in the column for the rest of the world correspond to the transfers paid for international cooperation in the field of environmental protection. These transfers can be financed either by the government or by households through non-governmental organizations.

5.144 In Table 5.9, financing by local units is increased by financing from abroad to obtain total uses of resident units, whereas earlier the financing from abroad was deducted from total uses to derive local financing needs.

Table 5.9. Financing of national expenditure on environmental protection

Millions of currency units

Financing units	Users/beneficiaries: Producers: Specialist producers	Producers: Non-specialist producers	Consumers: Households	Consumers: Government	Rest of the world	Total	Of which: current expenditure
Government	1 300	1 100	0	1 700	300	4 400	2 000
Corporations						0	
Specialist producers	800	0	0	0	0	800	0
Other producers	0	9 100	0	0	0	9 100	7 600
Households	0	0	3 570	0	0	3 570	3 570
National expenditure	2 100	10 200	3 570	1 700	300	17 870	13 170
Rest of the world	0	0	0	100	0	100	100
Uses of resident units	2 100	10 200	3 570	1 800	300	17 970	13 270

Source: SEEAland data set.

4. Net cost of environmental protection

5.145 Table 5.9 shows how total environmental protection by sector is directly funded. The fact that environmental activities are undertaken can be a source of revenue and Table 5.10 is a first attempt to take the financing requirement of Table 5.9 one stage further and to examine the net cost of self-financed expenditure when all the implicit revenue coming from undertaking the activity is taken into account. For industries, the objective of this complementary analysis is to obtain the supplementary costs linked to the environment. These production costs are not, on the whole, finally borne by producers; rather, they are part of the price they pass on to the purchasers of their products. For households, the objective is to know how much of what they pay is actually related to environmental protection. This form of analysis needs further elaboration and is presented here in this form as an indication of a possible supplementary analysis. At present, it is applied only to the current element of environmental protection expenditure.

5.146 For each sector, the starting point is the current element only of the total shown in Table 5.9 as the amount financed by each group of units.

5.147 For government, receipts of taxes on production from all environmental protection goods and services producers are deducted as well as any non-deductible VAT payable by these producers.

5.148 Some activities undertaken for environmental protection may lead to side benefits (savings on energy or raw material consumption etc.). Any such revenues or actual cost savings, when identifiable, should be deducted from the environmental protection gross costs. Together, these items are shown as “any other profits”.

5.149 Lastly, for all producers using environmental products, an estimate is made of the full cost of operating fixed capital by including the imputed or actual interest on fixed capital. For specialist market producers, this cost is offset by their net operating surplus which represents the actual return to their capital. Because this is already taken into account in the previous calculations, it is deducted here in order to prevent double counting.

5.150 Table 5.10 illustrates the net cost account resulting from the above operations. This table could be extended to include all environmental taxes and not just those earmarked for environmental protection. The result would then be the total “financial burden” or cost, by sector and for society as a whole, of environmental protection.

Table 5.10. Environment-related net cost burden

Millions of currency units

Elements of environment-related financial burden	Corporations		Consumers		Total
	Specialist producers	Other producers	Households	Government	
Financing of current national expenditure	0	7 600	3 570	2 000	13 170
Non-deductible VAT on current expenditure	0	0	0	- 270	- 270
Taxes on production	0	0	0	0	0
Any other profits	0	- 75	0	0	- 75
Interest on fixed capital less net operating surplus	1 000	1 200	0	700	2 900
Net cost of environmental protection	1 000	8 725	3 570	2 430	15 725
Environmental taxes	0	3 200	3 800	-7 000	0
Total environment-related burden	1 000	11 925	7 370	-4 570	15 725

Source: SEEAland data set.

5. Description of main data sources

Classifications and links to other systems

SERIEE and the OECD EPER system

5.151 So far, only two systems exist at an international level for the recording of environmental protection expenditure: the Eurostat's European System for the Collection of Economic Information on the Environment (SERIEE) and the OECD's Environmental Protection Expenditure and Revenues (EPER) system. The OECD collection system is used by both OECD and Eurostat to collect data on environmental protection expenditure that are in line with SERIEE but, at present, it does not exploit all the features of SERIEE. SERIEE is well documented, more extensive and subject to regular review and enhancement. Those interested in entering into greater detail in the area of environmental protection activities should consult the SERIEE documentation.

Classifications

5.152 Annex V contains details of the Classification of Environmental Protection Activities and Expenditure (CEPA).

5.153 Functional classifications are used to group transactions according to the purpose for which a transaction is undertaken rather than by its type or by the unit undertaking the transaction. Analysis by functional classification can be a good starting place for satellite account work but some problems may arise. For example, there may be transactions that serve several purposes and so cannot be subdivided by purpose. In such cases, the transaction may have to be classified according to the principal purpose. Hence, the data according to the SNA functional classifications alone may not provide a complete picture and additional analyses of some items may be necessary.

5.154 A clear distinction must be made between purpose and effect. For example, in the case of environmental protection, actions undertaken for other than environmental purposes can have positive environmental effects (for example, new technologies may lead to reductions in energy use, material consumption and discharges to the environment), whereas it is conceivable that actions undertaken with an environmental protection purpose may not actually have a beneficial environmental effect.

5.155 Classifications by purpose and functional classifications are presented in chapter XVIII of the 1993 SNA (COICOP, COPNI, COFOG and COPP). A revised version of these was published by the

United Nations (2000) as *Classifications of Expenditure According to Purpose*. Annex VI lists those categories of SNA functional classifications that are most relevant for the purposes of this chapter. As can be seen, the CEPA has been used as the basis of relevant parts of some of the functional classifications also.

Finding data sources

5.156 Identification of data sources begins with a description of environmental protection activities and their organization and institutional arrangement. Based on this, the organizations and statistical units (or classes of units) involved in environmental protection are identified. Box 5.4 gives an overview of the possible sources of primary data.

5.157 For ***government***, this kind of information is often available in published form and can be refined based on government organizational charts and budgets. The names of departments or budget lines or articles give a first idea of the administrative bodies involved in environmental protection. It may happen that some institutions are involved in environmental protection activities even though environmental protection is not their primary function (for example, the Ministry of Agriculture may subsidize environmentally friendly agricultural practices, or the Ministry of Transport may finance the construction of anti-noise walls).

5.158 In a second step, reports of activity, budgetary documents or financial statistics for these departments or institutions are collected. Some information may be readily available (for example, environmental research and development expenditure). The government accounts section of the national accounts department may have useful source data as well. It may be necessary, for example, for local governments to organize specific surveys about their expenditure for environmental protection for their domains of competence.

5.159 For ***enterprises*** specializing in producing environmental protection services such as waste or wastewater management services, the main data sources are industrial production surveys. Compilers have to approach the departments in charge of these surveys in order to know which regular data are available, and their timeliness and periodicity. Most producers of environmental protection services are classified in division 90 of ISIC. It is important to check with the people in charge of industrial surveys to determine whether producers classified in other divisions (such as division 41, Collection, purification and distribution of water) contribute substantially to the provision of environmental services.

5.160 The third main data source is specific environmental expenditure surveys of industries. These provide the primary data for in-house (own account) environmental protection activities by producers. Specific surveys often cover the current and capital expenditure for environmental protection of the mining, manufacturing and electricity supply industries. As far as possible, these surveys should be complemented with information and estimates for other industries (such as agriculture, construction, and transport).

Box 5.4. Overview of possible sources of primary data

Government activities
Government finance statistics and national accounts (COFOG etc.)
Detailed analysis of budgets (in particular central and regional governments, large cities)
Specific surveys on, for example, municipalities or associations of municipalities
Annual reports of, for example, government agencies or funds

Specialist corporations (for environmental protection services essentially under ISIC 90)
Service statistics
National accounts
Input-output tables
Turnover or tax statistics

Ancillary activities
Specific surveys
Data from business associations
Engineering estimates

Households
Data on final consumption expenditure (for example, from household surveys)

Non-profit institutions serving households
Annual reports of environmental organizations etc.
Government transfers to NPISHs

Clean products
Market data and expert assessment

Specific sources
Research and development statistics
Data on sewerage networks or waste disposal facilities (to estimate capital stocks)
Environment industry market estimates

Arranging data into EPEA accounts

5.161 In general, the raw statistical data have to be treated and rearranged into environmental protection expenditure accounts except when data from national accounts departments are available at a sufficiently detailed level.

5.162 In the case of specific industrial surveys, treatment may consist in grossing up or expanding results to cover the whole field that the compiler is interested in. As an example, for waste or wastewater management, it may occur that some (groups of) producers are not covered by the surveys. In this case, a specific assessment of these producers is necessary, based, for example, based on the share of the population served or other information.

5.163 An essential step in data treatment is to estimate the value of environmental services produced (the output) in a way consistent with the treatment in the national accounts. Industry production statistics and national accounts data will provide the value of the output directly. For government and in-house activities by producers, the main sources of data may provide only estimates of current and capital outlays. These data are converted into the components of a national accounts production account - specifically outlays for materials, energy or rentals into intermediate consumption, and wages and salaries into compensation of employees. In order to calculate the total value of output, the consumption of fixed capital has to be estimated as well, generally by using the national accounts procedures and assumptions.

5.164 In order to assure consistency of the estimates, data have to be organized according to national accounts practices: systematic comparison of supply and uses, and elimination of double counting when subcontracting is important. Subsidies paid by government for environmental protection also have to be identified, as they may modify the value of the recorded output.

5.165 As for the compilation of any account, EPEA compilers will have to make their own estimates based on all available information. This includes, for example, the use of physical data or of expert knowledge.

5.166 The transition process from raw data to accounts should be clearly documented, including the sources, methods and assumptions used for grossing up of raw data, data conversion or correction coefficients and the procedures for estimating missing data.

5.167 For environmental protection expenditure, typical data sources and their relation to the supply and use framework are given in Table 5.11.

Table 5.11. Typical data sources and their relation to the supply and use framework

Data source	Characterization of the statistical unit	Supply	Use
Specific surveys of environmental protection expenditure by businesses	Non-specialist producer with ancillary environmental protection activity	Ancillary output can be calculated based on own-account current and capital expenditure (transformed into cost of production)	Equals supply for the ancillary activities If surveys separately identify operating expenditure and the purchases of (external) environmental protection services within current expenditure, then use of marketed services can be identified as well
Government finance statistics, COFOG analyses, budget data, annual reports of environmental agencies or funds etc.	Often specialist producer	Market or non-market output can be calculated based on expenditure and revenues	Non-market part: collective consumption Market part: unknown, often households and small businesses
Data on ISIC/NACE 90[a] and other data sources on private and public producers specializing in environmental protection	Specialist producer	Market output	Unknown; often businesses, sometimes households (supply and use tables may be useful in determining users)
Household surveys, actual final consumption expenditure of households	Households	No	Can help to identify the purchases of marketed environmental protection services by households

[a] Statistical Classification of Economic Activities in the European Community (NACE Rev.1).

Main data sources and methods for assessing the environment industry

5.168 The main data sources are very similar to those for environmental expenditure and include standard statistics (for example, some ISIC categories) and specific surveys. The main approaches to measuring the environment industry are:

(a) Supply-side approach (specific surveys of environment industry producers etc.);

(b) Use-side approach (environmental protection and resource management expenditure);

(c) Integrated supply and use approach (not an independent method in itself but a combination of the supply- and use-side data within an accounting framework).

5.169 On the production side of the account, a distinction should be made between market output and non-market output. The outputs of non-market producers in government and ancillary producers are to be calculated based on costs of production. Estimation will be better if supply and use tables are disaggregated by environmental domain.

5.170 On the use side of the account, information on the uses of market output is generally incomplete so that estimates must be made based on informed judgement. Monetary (as well as physical) supply and use tables may be of some help in this estimation process, as well as physical data and price information (for example, the proportion of household waste collected relative to industrial waste).

National accounts

5.171 Where the national accounts are sufficiently detailed, most data necessary for the compilation of expenditure accounts are directly available. The national accounts usually include tables at a very detailed level and comprehensive databases on the various sectors of the economy. It is important for the compilation of the EPEA to have access to these databases and tables.

Production statistics

5.172 Specialized environmental protection producers are subject to regular surveys in the general statistical process (production statistics). These producers are mainly found in class 9000 of the ISIC. Through these surveys, several variables are collected: sales (by product according to the Central Product Classification (CPC) or specific national classification of products), intermediate consumption, compensation of employees, taxes paid on production, subsidies received for production, investments, employment etc.

5.173 Surveys of producers of other classes of the ISIC should also be considered. Although the principal activity of these producers is not environmental protection, they may produce environmental protection services as secondary output (recycling, construction, water distribution etc.). Specific environment industry surveys can provide useful data on secondary output of environmental protection services as well as data on producers of equipment and facilities specific to environmental protection (producers of pipes for sewerage systems, incineration plants etc.) which equipment and facilities constitute a source of data for the assessment of gross fixed capital formation for environmental protection.

Analysis of accounts of government and finance statistics

5.174 Several data sources exist for the activities of government units. The most widely used is based on the detailed analysis of budgets (in particular for central and regional governments and large cities) or government finance statistics. This analysis is part of the process of compilation of national accounts for the institutional sector for general government; however, the results are generally rather aggregated and a specific analysis has to be made for assessing environmental protection outlays of government. Starting from the list of the government units involved in environmental protection, the objective of this analysis is to derive the outlays for the production of environmental protection services as well as other outlays and receipts (transfers given and received, receipts from fees and charges etc.).

5.175 If government finance statistics do not provide enough detail, in some countries municipalities or associations of municipalities are surveyed in order to collect data on waste and wastewater collection and treatment activities. These data may cover various variables, from the physical quantities to the prices and the inputs used, including installations and facilities, investment etc.

5.176 Annual reports of government agencies or funds for environmental protection also provide data on the activities and outlays of these agencies, as well as their receipts (either from central or local government budgets or from specific environment-related taxes, charges or fees) and the flows of funds to other units (subsidies, capital grants and other transfers).

Industry expenditure surveys

5.177 Specific surveys are the main source for the assessment of the corresponding expenditure for ancillary activities. These surveys provide data on investments made for environmental protection (end-of-pipe equipment or installations, extra cost of integrated technologies) and often also on current environmental protection expenditure by industries (intermediate consumption, compensation of employees etc.). Data from business associations and engineering estimates also constitute a source for the assessment of expenditure by businesses.

Other sources

5.178 Household surveys may constitute a source for assessing the consumption expenditure of households on waste and wastewater collection and treatment services. Expenditure on cleaner goods and services (anti-noise windows, refuse bins, septic tank emptying services, car exhaust regulation etc.) will rarely be surveyed and may be estimated based on production statistics, market analysis or studies. Analysis of the annual reports of the main environmental non-profit institutions provides information on their activities, expenditure and receipts. Data on financing by government may also be available.

5.179 Various other sources may complement the previous data: construction statistics (investments in sewerage systems, wastewater treatment or incineration plants, anti-noise walls etc.); business associations (supply or market of connected and adapted products, level of environmental protection in the main industries); environmental reports of big firms (in the noise domain: transportation firms, airport management entities; in the air domain: refineries, power plants etc.); non-profit institutions; either public or private research and development statistics, when they are sufficiently disaggregated; physical data on sewerage networks; waste disposal facilities (to estimate capital stocks); environment industry market estimates; price or employment statistics.

5.180 Some of the data needed will have to be based largely on estimates and calculations. For example, expert knowledge and specialized literature may offer coefficients for the costs of adapting vehicles to meet environmental requirements. The total expenditure can then be calculated based on the total number of new vehicles.

5.181 In order to ensure an efficient search for primary data, a first step is an analysis of the country's organization of environmental protection. Table 5.12 illustrates how environmental protection might be organized. A large X in a cell indicates that this is typically an important component of activities and expenditure in the domain concerned; a small x indicates a small component.

Table 5.12. Illustration of environmental protection competencies/production activities

Subsector/entity (Domain)	General administration	Waste	Waste water	Nature protection	Air	Etc.
Central government	X	-	-	x	x	
Regional governments	x	x	x	X	-	
Specific government agencies	X	-	x	X	-	
Associations of municipalities	-	X	X	-	-	
Municipalities	-	X	X	-	-	
Publicly owned disposal enterprises	-	X	X	-	-	
Private disposal enterprises	-	X	x	-	-	
Non-profit institutions	x	-	-	X	-	
Ancillary activities of mainstream industries	-	X	x	x	X	
Households	-	x	x	-	x	

Note: A dash (-) signifies zero (see para. 5.185).

Reconciling supply and use information

5.182 The supply of environmental protection products by the environmental industry, national expenditures on environmental protection, and environmental expenditure accounts are closely related but not exactly the same, so it is worth explaining exactly how they relate to one another. The environmental protection expenditure accounts (EPEA) comprise derived data and thus it is not a primary source; but the fact that there are accounting identities linking the entries helps to improve data consistency and plausibility. Indeed, since it is not always easy to obtain the information needed for the supply of products by the environment industry, the interaction with the EPEA is often used to improve both sets of estimates.

5.183 Table 5.13 attempts to show this relationship diagrammatically. The box on the left shows the supply coming from the environment industry in the column headed "production". The column headed "imports" shows the other source of supply of environmental protection products. The entry for non-environmental protection products in the last row of the left hand box is a reminder that much of the economy lies outside the scope of the environment industry.

5.184 The box on the right shows the entries in the EPEA. Those that are shaded are the ones that appear in the calculation of the national expenditure on environmental protection services in Table 5.8.

5.185 Blank cells indicate that the cell is zero by definition. A cell containing "0" indicates that it is theoretically possible that there might be an entry there, but in practice it is usually safe to assume the figure is either zero or insignificantly small.

5.186 The arrows between the two boxes give an indication of which data set is likely (but not certain) to provide the more reliable estimates. For the two rows where the arrows appear in parentheses, all data sources are very tenuous and this is more a hypothetical link than one that can be implemented in current practice.

5.187 For the EPEA, the environment industry is a source of data on the supply of environmental protection services, products used for environmental protection capital formation and connected and adapted products.

Table 5.13. Links between the supply of environmental protection products by environmental industry and imports, national expenditure, and environmental protection expenditure accounts

	Supply			Intermediate consumption			Capital formation		Final consumption		
	Production	Imports		Specialist environmental protection producers	Ancillary activities	Non-environmental protection activities	Specialist producers	Other producers	Households	Government	Exports
Environmental protection services											
- Non-market	X		→				X		X	X	
- Market	X	X	↔	X	X	X	X	X			(0)
- Ancillary	X		→	(0)	(0)	X					
Environment-specific materials	X	X	(←)	X	X	X	(0)	(0)	(0)	(0)	(0)
Environment-specific equipment	X	X	←	(0)	(0)	(0)	X	X	(0)	(0)	(0)
Cleaner technologies	X	X	←	X	X	X	X	X	(0)	(0)	X
Cleaner products	X	X	(←)	X	X	X	(0)	(0)	X	X	X
Other products	*	*		*	*	*	X	*	*	*	*

Note: An asterisk (*) indicates a cell where there would, in principle, be large entries in a full supply and use table but that is not relevant for the purpose of the present chapter, as these are non-environmental products and are not used for environmental protection.

5.188 The main differences between the two sets of data are as follows:

(a) The EPEA includes only the expenditures of resident units, whatever the origin of the products (domestic production or imports), whereas the environment industry covers the production by residents units, whether used domestically or exported;

(b) Not all entries for a full production account for the environment industry are shown. These would include all ancillary production and all capital formation for that industry. For the EPEA, only ancillary activity, intermediate consumption, final consumption and capital formation in environmental protection products are included except for capital formation in non-specialist equipment used for environmental protection.

5.189 The data in the shaded cells that go from the EPEA to the national expenditure on environmental protection form a subset of the full supply and use entries. As explained above, intermediate consumption by the environmental protection industry of its own products is excluded to avoid double counting.

Transfers relating to environmental protection services

5.190 A full discussion of the role of transfers and, in particular, environmental taxes appears in chapter VI. The present section concentrates on procedures that will help identify the flows needed for the compilation of the elements in the expenditure accounts relating to financing from other sources.

5.191 Transfers have an impact on the financing of environmental protection expenditures. In order to identify transfers related to environmental protection, the procedure illustrated in Table 5.14, is proposed, encompassing:

(a) *A table of intragovernmental transfers* that shows who pays and who receives each transfer should be established. Many transfer payments are between different levels of government, for example, from central government to an environmental fund or to local authorities. Transfers that are identified by both the donor and the beneficiary in the basic data should be set aside, as, for example, in the case where basic data include investment grants from the central State to local authorities as well as the corresponding investment undertaken at the local level. However, there may also exist "open-ended" transfers where information on the counterpart entry does not appear in the basic data available, for example, transfers to a government agency whose annual report is not available. In such a case, the transfers can constitute a basis for estimating the expenditure of that agency.

(b) *A table of transfers among sectors*. Normally, transfers will go only from the government sector to the other sectors (households, corporations, and non-profit institutions) but the reverse - for example, large donations or earmarked pollution taxes - can also be true. The same principles apply as above: if the expenditures that correspond to (are financed by) the transfers are included in the primary data, the transfers should be consolidated (netted) out to avoid double counting. Some kinds of transfers will, by definition, have no counterpart in basic data (for example, international cooperation).

Table 5.14. Tables of transfers related to environmental protection services

	Donors							
Beneficiaries	Federal govern-ment	Federal funds	Regional govern-ments	Regional funds	Municipalities	Other	***Total received (1)***	Balance (1)-(2)
Intra-governmental transfers								
Federal government								
Federal funds								
Regional governments								
Regional funds								
Municipalities								
Other								
Total given (2)								
Preferential loans to other sectors								
Industries								
Households								
Total preferential loans								
Cash grant equivalent of loans								
Transfers to other sectors								
Industries								
Households								
Rest of the world								
Total transfers to other sectors								
Total transfers including loans								

D. Extensions and applications of the accounts

5.192 The present section deals with the extension and application of the framework presented in earlier sections. Linking expenditure with physical data represents an important attempt at quantifying the relationships between the expenditure undertaken and the environmental damage avoided. The compilation of satellite accounts in constant prices, for the purpose of assessing the changes over time free from the effects of inflation, is also discussed.

5.193 Two practical instances of implementation of the proposals put forth in this chapter follow. The first relates to the estimation of environmental protection expenditure in Germany. The second concerns the estimation of research and development expenditure in Canada.

1. Links to physical data

5.194 As for other satellite accounts, the usefulness of accounts of environment-related activities and expenditure can be enhanced by establishing links with physical data, particularly with respect to emissions collected, treated or avoided, and the tax bases for environmental taxes (fuel use, vehicles in circulation etc.) as well as protection equipment and facilities. The main instruments for this linking are physical flow accounts (for example, the links to emissions described in chap. IV). Because physical data or indicators about environmental protection equipment and facilities are necessary for the compilation of emissions (and emission accounts), the links between physical data on equipment and monetary expenditure need to be established.

5.195 Some links are easy to establish, in particular links to treatment capacities, or waste or wastewater treated. One example is the relationship between wastewater management and actual discharges to water and the quality of rivers. This link is useful for the purpose of exploring whether the amounts spent have been used efficiently and whether spending is at an adequate level in relation to changes in emissions and water quality. However, some links are more difficult. Expenditure data on pollution abatement measures are normally not available at a sufficiently detailed level (by air pollutant, say). Abatement measures often reduce emissions for several pollutants and not just one. Further, emissions are the result of many factors, including the level of activity and savings in the use of raw materials or energy, as well as other measures not described in environmental protection accounts. The result is that linking physical data on emissions with a description of environmental protection expenditure for some domains, mainly air emissions, requires a careful and detailed analysis.

5.196 For linkages to the physical data, the environmental protection accounts must, as far as possible, use the same classifications that are used in the physical flow accounts. Experience has already shown that environmental expenditure and environmental taxes can be presented using the same industry classifications as are used in the physical flow accounts, thus providing consistent information for each industry or branch of production on such items as energy use, energy taxes paid, air emissions and expenditure on the protection of air. Such data sets facilitate attributing the changes in emissions (including emissions avoided) to the different factors that caused these changes.

2. Time series and constant prices

5.197 The introduction of environmental protection goods and services leads to discontinuities over time. For example, because in many countries neither cars without catalytic converters nor petrol containing lead is sold any longer, a long time-series of expenditure on cars or petrol is not likely to be strictly consistent over the time period. This is a problem in current price series but it is even more acute in constant prices.

5.198 Suppose the car with a catalytic converter is regarded as being a joint product, a car without a converter and a “bundle” of environmental protection services represented by the converter. The introduction of the converter would then represent the introduction of a new product into the expenditure patterns of the purchaser of the car. Treating the converter as a new product will result in a greater quantity of cars sold in constant prices as opposed to the case in which the converter is treated as producing an increase in the price of the car. The same effect will also result if the addition of the converter to the car is regarded as a quality change.

5.199 A more direct example concerns the addition of an advanced treatment module to wastewater treatment. Installation gives rise to an increase in the expenditure (and prices of wastewater treatment services) that should be treated as a quality change converted to volume terms and not as just a pure price increase.

5.200 This effect is not necessarily treated analogously across the accounts. New products bought by households as final consumers, for example, trash compactors, will give rise to an increased volume measure. The same is true for new products bought by non-market producers. The problem, therefore, is particular to market producers other than those producing environmental protection goods and services. It is impossible for an analyst to determine whether increased spending on environmental protection increases or decreases the growth of the economy without knowing whether the increased costs have been treated as a price or volume effect. Selective collection of waste is generally more expensive than non-selective collection, but the positive environmental effects are greater. Purification of water before distribution may become more expensive when the quality of the water in the environment decreases, although the final product remains the same (drinkable) water. To the extent that costs are treated as a price effect, growth rates based on constant prices of a year before and those based on prices of a year after the introduction of the new environmental protection will differ from each other even though both treat environmental protection as a price effect. The more the impact of environmental protection is treated as a quality or volume effect, the more the growth rates will increase based on an older price, but when the new quality is built into the new price base, the growth rate will tend to be lower.

3. Environmental input-output analysis: the experience of Germany

5.201 The main purpose of an environmental protection input-output table (EIOT) is to investigate structural and other effects on the total economy of producing environmental protection services (Schäfer and Stahmer, 1989). This linkage is the only means by which the effectiveness of environmental protection measures can be examined, and to this end the EIOT is designed to match the physical input-output tables (PIOT) (Stahmer, Kuhn, and Braun, 1996), thus building a bridge between environmental protection measures and material and energy flow accounts. This bridge is created by the use of identical classifications and the parallels between the data in physical and those in monetary units. As in the environmental protection expenditure account, the EIOT separates internal and external environmental protection services and fixed capital formation for environmental protection.

5.202 The Federal Statistical Office of Germany has calculated a comprehensive EIOT that links the German national accounts and the European SERIEE system for the reporting year 1990. The calculation procedure was based to some extent on a former EIOT that had been produced for Germany for 1980 and 1986.

5.203 In general, the task is to break down the regular input-output table into non-environmental and environmental sections. The required statistical information is mainly found in the expenditure aggregates as presented in earlier sections of this chapter. For the German EIOT, detailed figures for different expenditure categories by industries (operating expenditure for different types of commodity groups, compensation of employees, consumption of fixed capital and gross fixed capital formation by commodity groups) for the most important environmental domains according to the CEPA classification were available or estimated. The frame of reference and starting point for the EIOT, in terms of the total economy, were the input-output table at producers' prices. The input-output table distinguishes 58 industries, but it was impossible to show this degree of detail in the German EIOT. Therefore an aggregation into 15 industries was made, with industries that are environmentally important shown separately wherever possible.

5.204 As with the expenditure accounts, the EIOT highlights internal and external environmental protection services for industries and fixed capital formation for environmental protection as part of the total gross fixed capital formation.

5.205 ***Internal services*** result from ancillary activities and are produced and used for own purpose. They are shown in the EIOT not as separate industries but as parts of the industries to which they belong.

5.206 In Germany, ***external environmental protection services*** supplied to others are produced by general government and by private and public enterprises. For external services, separate industries are distinguished within the EIOT. The total output value of these new industries is the benchmark figure for the distribution of output among users of external environmental protection services. The output value was mainly based on the aggregation of data of general government for sewage and waste disposal functions (fees, reimbursements) and turnover figures of private and public enterprises. For a description of the input side in the EIOT, the intermediate consumption needed for the production of external services had to be determined by commodity group, along with the components of gross value added. The distribution of the total output value and the external services imported among the user industries and private consumption was needed for the use side. For the EIOT, the results of the 1990 PIOT on physical waste and sewage volumes disposed of externally formed the starting point. These volume figures were multiplied by average disposal charges to estimate purchases of environmental protection services by industries and final use categories. Owing to limitations in primary data, the EIOT did not include secondary production of external disposal services by non-environmental industries; however, this is probably not very important in Germany.

5.207 The third important data set in the EIOT concerns ***fixed capital formation*****,** which was again divided into specific environmental domains and commodity groups, as part of the fixed capital formation of the total economy.

5.208 The fact that, through the addition of expenditure for internally produced disposal services and purchases of external services, total branch-specific environmental protection expenditure could be obtained, enabled a comprehensive comparison of the expenditure of the different industries.

4. Environmental research and development: the Canadian experience

5.209 Expenditures by the Canadian federal Government on environmental research and development (R&D) represented between 8 and 9 per cent of total federal government R&D spending between fiscal years 1995/96 and 1998/99. Intramural[17] environmental R&D expenditures represented 6 per cent of total federal intramural R&D spending; these expenditures were equal to Can$ 85 million in 1998/99, a 14 per cent drop from the amount for 1995/96. Federal extramural[18] R&D expenditures on environment were equal to $44 million in 1998/99, a 12 per cent drop from the amount for 1995/96.

5.210 In comparison, industry spending on environmental R&D (intramural[19] spending only) had represented 2 per cent of total industry R&D in 1995. Led by engineering offices and the scientific services industry, environmental R&D spending undertaken by Canadian industry totalled $165 million, up 22 per cent from the 1993 level. In fact, environmental R&D spending was undertaken by two categories of firms, those whose principal or secondary production was environmental goods and services and those that were users of environmental products.

[17] Intramural government R&D spending: government spending on R&D excluding non-programme costs.

[18] Extramural government R&D spending: R&D performed outside departmental programmes.

[19] Intramural industry R&D spending: expenditures for R&D performed within a firm.

Data sources

5.211 Statistics Canada estimates environmental R&D spending by industry and government from two surveys, the Research and Development in Canadian Industry Survey and a survey on federal scientific activities.

5.212 Statistics on industrial R&D expenditures attributable to pollution abatement and control and environmental protection were derived from the industrial survey and available for the period from 1990 to 1995. Firms surveyed included both companies and industrial research institutes.[20] These firms covered those claiming an R&D tax credit, firms reported by government organizations as R&D contractors or grantees, firms reported by other companies as financing or performing R&D, and firms identified from a variety of other sources as potential R&D performers. R&D expenditures covered only intramural expenditures, that is, expenditures performed within the firm as opposed to R&D performed for a firm by contractors.

5.213 In the 1995 industrial survey, firms were asked to estimate the "percentage of total R&D expenditures attributable to prevention, treatment and reuse of pollutants and wastes". R&D was defined as the systematic investigation carried out in the natural and engineering sciences by means of experiment or analysis in order to gain new knowledge and create new or significantly improved products or processes devoted to the reduction or elimination of pollutants and wastes.[21]

5.214 Federal government R&D was allocated by socio-economic objective, based on the Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets (NABS) produced by Eurostat. The control and care of the environment/protection of the environment objective was defined as follows:

> Scientific activities into the control of pollution, aimed at the identification and analysis of the sources of pollution and their causes, and all pollutants, including their dispersal in the environment and the effects on man, species (fauna, flora, micro-organisms) and biosphere. Development of monitoring facilities for the measurement of all kinds of pollution is included. The same is valid for the elimination and prevention of all forms of pollution in all types of environment.

Challenges

5.215 There is under-coverage of environmental R&D expenditures owing to limitations in data coverage, definitions and overlap with other types of R&D spending.

Coverage

5.216 Some caution is required in adding figures on industry environmental R&D to estimates of business environmental protection expenditures owing to variations in the universe of the different surveys used. The industrial R&D survey covered specific types of firms, and may be described as follows:

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[20] Industrial research institutes dedicated to research projects for a specific industry, such as the paper and allied products industry, and funded jointly by industry, Governments and universities.

[21] The 1996 definition was broadened to include a question on the existence of important potential environmental benefits related to total R&D reported. These environmental benefits were defined as potential energy savings; reduction in use of raw materials or waste generation either from increased efficiency, recycling or closed-loop systems; and design changes resulting in products that were less damaging to the environment in their use or disposal.

(a) Firms that claimed an R&D tax credit or that were identified by other organizations or companies to perform R&D are included;

(b) Both enterprises and industrial research institutes were covered. Indeed, in many instances, environmental R&D is conducted by an institute for a particular industry and is funded through a joint effort by industry, industry suppliers and government;

(c) The industry coverage was a mix of users and producers of environmental goods and services;

(d) In addition, only intramural expenditures were estimated through the industry R&D survey, which excludes the contracting out of R&D services (included in other business environment surveys).

5.217 On the government side, the federal government data are the only estimates available of R&D spending related to environmental protection. There is no information on the size of the environmental R&D performed by provincial and municipal governments.

Definitions

5.218 The definitions of environmental R&D are limited as shown above. They related to pollution abatement and control R&D only and exclude R&D with environmental benefits if it was not performed for pollution abatement and control purposes. Further work is required to clarify the definition of environmental R&D expenditures and to expand the definition to cover R&D in areas such as pollution prevention, energy conservation etc.

Overlap with other types of R&D

5.219 There is some overlap between statistics on environmental R&D and statistics on energy R&D. Government and industrial R&D on energy technologies include projects on energy conservation, fossil fuel recovery, and renewable energy, as well as R&D on nuclear power and other fuel systems. Expenditures on energy R&D, while not specifically aimed at conservation or climate change, for instance, may contribute to reduction of air pollution (for example, by greenhouse gases) through lower fossil fuel consumption. The problem is to distinguish between R&D on energy conservation and substitutes and R&D on fossil fuel development or nuclear power.

Distinction between financing and execution of R&D

5.220 Statistics Canada's data on environment R&D do not provide a distinction between those agents that finance the R&D and those that execute the R&D, except in the case of federal government R&D. At the federal level, there is a distinction between intramural R&D which is performed by the department itself and extramural R&D spending which comprises expenditures on R&D performed outside federal government departments but on behalf of the federal government. Industrial estimates of environmental R&D include intramural R&D, that is, R&D performed inside the firm. However, there is no information on the source of funding of industry R&D.

Chapter VI. Accounting for other environmentally related transactions

A. Overview

1. Objectives

6.1 Chapter IV discussed how to link monetary flows associated with production, consumption and accumulation with physical flows, covering not only these activities but also the absorption of natural resources and ecosystem inputs and the generation of residuals. This corresponds to the part of the SNA covering the goods and services account, as reflected in supply and use tables and input-output tables.

6.2 Chapter V looked in particular at environmental protection expenditure and explored how it could be portrayed within the system elaborated in chapter IV. This involved identifying certain products and activities particularly relevant to the environment and showing how they could be identified in the supply and use tables.

6.3 Government not only provides but also intervenes in the use of environmental services, for example, by controlling use of the environment through legislation. This process is sometimes referred to as "command and control". One example entails restrictions on landfill sites; another involves legislation to ensure restoration of the environment after a production process ceases for instance, when a mine closes. Another way government intervenes in the use of the environment is by levying environmental taxes. Increasingly, though, Governments are moving away from legislation as a means of protecting the environment towards "cap and charge" policies instead. In practice, to date, this has meant issuing licences, sometimes free, sometimes for a fee, that entitle the owner to some sort of exclusive right to use a given environmental asset or a part of it. Emissions trading permits and fishing licences are examples. Whenever a monetary transaction results from these interventions, it is recorded in the SNA. The major objective of the present chapter is to examine what sort of transactions are involved and how they are recorded.

6.4 Once all these types of transaction have been enumerated, a complete set of satellite accounts, fully consistent with the SNA but identifying all environment-related transactions, can be articulated. Section E shows how this can be expressed within an extended matrix presentation such as the social accounting matrix (SAM) presented in chapter XX of the 1993 SNA. It, too, can be augmented by the sort of physical data discussed in chapters III and IV of the present publication to produce a hybrid SAM. This is the fullest form of a NAMEA and it is described briefly here as a means of presenting the integration of all the flows discussed in chapters III - V and this one.

2. Economic instruments

6.5 For present purposes, we are concerned with only those instruments invoked by government in relation to activities encompassing the use of environmental assets or media.[22] An economic instrument is a means by which decisions or actions of government are made to affect the behaviour of producers

[22] For a survey of the use of economic instruments for environmental protection in OECD countries, see OECD (1994a).

and consumers by causing changes in the prices to be paid for these activities. Environmental taxes fall into this category, as do direct charges for government-provided environmental services. In fact, the boundary between these two is rather fluid and may change noticeably over an extremely short period of time.

6.6 Of increasing importance is the role of charging for the use of environmental media. In some countries, government is assumed to be the public guardian of environmental resources and thus controls them on behalf of the public at large. In other countries, environmental resources are mainly held privately; but, even so, if there is a charge levied by the owner on the user, then this needs to be recorded in the accounts. Both these arrangements are discussed in this and subsequent chapters.

Taxes versus fees for a service

6.7 Not very long ago, the taxes paid by households and businesses on their property contributed to the costs of government (often local government) for a variety of services including the provision of piped water and the collection of refuse. In many countries, these services have, in recent years, been separated from general government services and the charges made to households and businesses regarded as payments for a service rather than a tax. Within the national accounts, it matters less who provides the service than whether the charges imposed relate to the service and are sufficient to cover all or most of the costs of providing it. Thus, payments for garbage collection may be a payment for a service even if it is entirely government-run. It is increasingly seen, though, that services that can recover their costs through direct charges operate in the private sector, while government concentrates on those services where support from its funds is deemed to be in the public interest. Fees that represent a payment for a service should be covered in the flows already described in previous chapters.

6.8 The role of taxes in the management of environmental resources is one of discouraging particular forms of expenditure by imposing a tax that increases the price of the products or the costs of production of the activities concerned. Sometimes, the revenues from such taxes may be designated to remedy particular forms of environmental damage. Even where no such direct link exists, it is advisable to have a measure of taxes with an environmental base so that, subsequently, these amounts can be contrasted with estimates of the environmental damage associated with the activities being taxed. The definition and measurement of environmental taxes are discussed in section B.

Property income and property rights

6.9 Assets may be acquired, disposed of or used up and, in the case of non-financial assets, all these events are recorded in the capital account of the SNA. (Similar transactions in respect of financial assets are recorded in the financial account but they are not the subject of concern here. Unless otherwise specified, throughout the SEEA, “asset” refers to a non-financial asset.) Once an asset is acquired, it is entered in the balance sheet of the owner, and this value is altered by disposal, using up or any other change in the volume or any value of the asset. Chapter VII is devoted to establishing the extent of environmental assets, placing a value on these and tracking the changes in their value in balance sheets. The interest in the present chapter is to consider transactions that occur when the asset is used in a production process.

6.10 In the SNA, production gives rise to income, value added, which is part of GDP. Value added is partitioned among the return to labour (compensation of employees), the payments to government of other taxes on production (less any similar subsidies) and the operating surplus which represents the initial return from the use of produced assets (fixed capital) and any non-produced assets. From this, the producer must make a payment to the owners for the use of any non-produced and financial assets he has been lent. In order to identify such payments, it is necessary to consider how the ownership and use of assets are recorded. Another way of describing this is to say we need to investigate property income and property rights.

6.11 The SNA defines an asset as an entity over which an ownership right can be enforced and from which the owner can derive benefits by holding or using it over a period of time (1993 SNA, para. 10.2). By definition, then, all assets are economic assets. In common usage, assets may also be described as property (not to be narrowly interpreted as applying only to land and buildings). Property rights are the rights that establish ownership of an asset and thus the right to determine who may and may not use it. Property income is the income flow that the owner of a non-produced or financial asset receives from allowing some other unit to make use of the asset. Most property income relates to the interest and dividends paid for the use of financial assets. Property income relating to the use of non-produced assets is called rent and, in many cases, encompasses rent on land.

Using some other unit's assets: rents and rentals

6.12 If a produced asset owned by an enterprise, such as a car or a tractor, is leased out by that enterprise, the income earned is part of production and is included in the value of output and GDP. This is not the case for financial leasing, where the payments from the user to the owner are recorded as financial transactions. Payments for the use of another unit's car or tractor are treated as final or as intermediate consumption depending on the case. These payments are called rentals in the SNA to distinguish them from rents. Whereas rent is the income derived from leasing out a non-produced asset, rental is the income derived from the leasing out of a produced asset. Rental contributes to GDP. Rent (and other property income) represents a redistribution of operating surplus – a transfer income from the unit using the non-produced (or financial) asset to the owner of the asset.

Recognizing new property rights and new assets

6.13 Increasing control over the right to use different environmental assets, either natural resources as inputs or environmental media as sinks for residuals, has meant that this right has become scarce. In consequence, it acquires a monetary value and thus comes to be regarded as an asset in and of itself giving rise to property income. The institutionalization of such rights is another form of economic instrument that is relevant to the environment. Acquisition of these rights and disposal of them must therefore be recorded in the capital account, just as acquisition and disposal of land have always been subject to such recording.

6.14 The recognition of such property rights and the creation of legal instruments that give them effect constitute a new and developing field. Not all of these instruments are described in the SNA because in 1993 not all of them existed. (The use of the radio spectrum for mobile phones is a case in point.) Nor can our description be exhaustive and cover every eventuality. However, some instances are discussed at length in section C in order to illustrate the considerations that must be taken into account when determining the appropriate type of recording for such an asset.

The cost of using one's own assets: consumption of fixed capital

6.15 Property income flows and rentals are recorded in the SNA only when the user of an asset is not also its owner. Using one's own assets also gives rise to income although this is not separately identified as such. If a farmer owns both land and a tractor, part of his operating surplus represents income arising from the use of these assets. In the SNA, there are no entries recorded for imputed rent on the land or imputed rental on the tractor. However, the tractor is a produced good that must have been paid for by the farmer. It is treated as capital hence the cost is not included in intermediate consumption. Instead, the cost is spread over a period of time corresponding to the period during which the tractor has been in use (its "life") and is recorded in an item known as the consumption of fixed capital. In aggregate, this is the item that distinguishes gross from net domestic product and its deduction from measures of production is necessary to derive a measure of income consistent with the idea of keeping fixed capital intact.

6.16 Consumption of fixed capital also appears in the 1968 SNA but increasing environmental consciousness has meant a re-examination of what the concept covers and how it should be measured and recorded. Particular instances of concern involve drilling platforms which, when no longer required, can no longer be left in situ or simply sunk at sea, and nuclear power stations which must be carefully decommissioned at the end of their useful lives. Legislation to enforce these clean-up costs is another form of economic instrument introduced for environmental policy purposes. The implications of these considerations are discussed in section D.

3. Identifying all environmental flows in the accounts

6.17 The versions of the hybrid supply and use tables described in chapter IV do not contain details covering the issues discussed in chapter V and the present chapter. In section E, the location of environmental flows throughout the income and capital accounts of the SNA is discussed. The means to express these in matrix form in order to reach a hybrid version of a full national accounting matrix is also provided.

6.18 Like the hybrid accounts in chapter IV, the matrix in Section E also contains the physical extensions for resource input and residuals outputs. Also as in the accounts in chapter IV, no changes are made in the fundamental accounting principles of the SNA, so that the macroeconomic aggregates and other indicators coming from the full hybrid accounting matrix are still strictly consistent with the regular national accounting totals.

4. Scope and limitations of the accounts

6.19 It is not possible in a chapter of this length to enter into all the details of the national accounting treatment of the intangible non-produced assets created by the establishment of new property rights. In some cases, the novelty of the devices being introduced is such that the correct treatment within the 1993 SNA is still the subject of some discussion. The consequences of new conventions on property rights, for example, those that might be invoked concerning the buying up of carbon sinks in other countries as could happen under some version of the Kyoto Protocol (United Nations, 1997b) to the United Nations Framework Convention on Climate Change (United Nations, 1994) may well provoke further discussion and controversy in the future.

6.20 The borderline between taxes and payments for services is fuzzy, as indicated above. If the goal is to create series that are comparable over time within one country or across a number of countries, it may be desirable to achieve that goal to consider taking a different position, namely, that payments are taxes and represent intermediate or final consumption. It should be carefully noted, though, that some variations of this nature may lead to results that are not strictly consistent with the national accounts as published.

6.21 Lastly, it should be noted that there are some asymmetries in the 1993 SNA that carry over to the presentations suggested here. From an environmental point of view, it may be highly relevant to consider the rent element of operating surplus due to a unit for the use of its own non-produced asset or the use of one owned by some other unit but for which no rent is charged explicitly. Similarly, while costs for the using up of fixed assets in the form of consumption of fixed capital are regarded as a deduction from gross income, the decline in the value of non-produced assets is not so regarded.

Chapter X discusses how the accounts might be modified to achieve symmetrical treatment of these issues.

B. Environmental taxes

1. Environmental taxes and specific taxes

6.22 Although few environmental taxes are directly earmarked for environmental protection activities, there is an obvious interest in seeing how the revenue from such taxes compares with the cost of the use made of the environment. Not all damage arising from this use is remedied through environmental protection activities, of course, but that there is a potential link between this source of revenue and the possible costs (to be discussed in chaps. IX and X) is another reason to delineate exactly what is meant by an environmental tax. Hence, a means of identifying such taxes is also given in this chapter.

6.23 In the environmental protection expenditure account, the term "specific taxes" is used for a subset of taxes that contribute to the financing of environmental protection. The revenue from specific taxes is regarded as being earmarked for environmental protection. The term "hypothecated" is often used by economists to describe taxes that are earmarked for a specific purpose. The earmarked, or hypothecated, tax is used to subsidize the production of environmental protection services; to finance non-market activities; to finance investment grants (gross capital formation) of non-market specialist producers; or to pay other current or capital transfers for environmental protection. Specific taxes are taken into account in the analysis of the financing of environmental protection with the exception of those taxes already included in national expenditure, for example, the proceeds of earmarked landfill and water pollution taxes are considered costs of production of environmental protection activities and, as such, they are not taken into account in the financing of environmental protection (see chap. V for detail).

2. Environmental taxes and sales of environmental protection services

6.24 When classifying government receipts, the distinction between taxes and sales of services is sometimes difficult. Whatever the name of the payment (rate, charge, fee etc.), when the payment is seen to be commensurate with the service provided, the payment is classified in national accounts in general, as well as in the SEEA, as purchase of services.

3. Environmental taxes in general

6.25 Environmental taxes are an important economic instrument for environmental protection. Revenue data for environmental taxes provide information on the structure and importance of environmental taxes within the taxation system. Such information is useful in a policy context of "green" fiscal reform. A basic aim of green fiscal reform is to change the structure of taxation systems so as to reduce the tax burden on labour and to increase the tax burden on the use of the environment (the so-called double dividend).

6.26 OECD, Eurostat, the International Energy Agency (IEA) and the European Commission Directorates-General for Environment and Taxation have developed a statistical framework on environmental taxes (Eurostat, 2001b). The framework was based on the definition of an environmental tax as "a tax whose tax base is a physical unit (or a proxy of it) that has a proved specific negative impact on the environment". It was felt that the tax base provides the only objective basis for identifying environmental taxes for the purpose of international comparisons. This definition places emphasis on the potential effect of a given tax in terms of its impact on the costs of certain activities or the prices of certain products. Other criteria such as those based on the name given to the tax or the purpose of the tax as expressed by the legislator or the fact that the revenues from a tax are earmarked for environmental purposes were therefore not used, although these criteria can still be useful when identifying environmental taxes in a national context.

6.27 The definition gives an idea of the key concept that should be measured. It also provides a guideline for the assessment of newly introduced taxes. However, the definition still leaves room for debate on borderline cases (for example, VAT on energy products or taxes on the purchase of land, tourism, resource extraction etc.). The key issue for ensuring international comparability is therefore the list of environmental tax bases (see Box 6.1) as agreed by the institutions involved. These tax bases (often physical units) allow for a direct link with physical accounts.

Box 6.1. Categories of environmental tax bases

- Measured or estimated emissions to air
- Measured or estimated emissions to water
- Energy products
  - Energy products used for transport purposes
  - Energy products used for stationary purposes
- Transport
  - Based on distance driven (per kilometre, per mile)
  - Import or sales of vehicles
  - Annual vehicle taxes
  - Other
- Wastewater discharges (not measured)
- Agricultural inputs (fertilizer, pesticides)
- Waste
  - General waste collection and treatment (waste collection, landfill)
  - Individual products (packaging materials, batteries, tyres, lubricant oils etc.)
- Ozone depletion (CFCs, halons)
- Noise

Source: Eurostat (2001b).

6.28 Since for an individual country, there may be rather few environmental taxes, the following aggregated groupings of environmental taxes may be used:

Energy taxes (including CO_2 taxes)

Transport taxes

Pollution taxes (on emissions to air and water, waste, packaging, pesticides, CFC, noise etc.)

Resource taxes (water abstraction, sand and gravel etc.)

6.29 It should be noted that resource taxes (as part of environmental taxes) do not include taxes on oil and gas extraction. The SNA specifies that these should be treated as payments of rent to the government as owner of the resources and not as taxes (1993 SNA, para. 7.133). The SEEA follows this recommendation, as explained in chapter VII. These payments to government generate important revenues in a limited number of countries. Even if such payments were to be classified as taxes, they should not be classified as environmental taxes for a number of reasons:

(a) It is the use of fossil fuels rather than the extraction per se that is environmentally harmful (setting aside the question of leakages and spills during extraction);

(b) The price of fossil fuels is largely determined by the world commodity markets and taxes levied in a particular country have negligible influence on this price;

(c) Given that few countries possess significant oil and gas reserves, including these payments as environmental taxes would lead to lack of comparability for this item across countries with or without reserves.

6.30 The basis for the identification of environmental taxes will often be tax revenue statistics. A list of taxes must be set up that allows environmental taxes to be separated from all other taxes and assigned to the detailed or aggregated classification above. Allocation of tax payments by detailed industries can be made, possibly by using the physical tax basis to disaggregate the aggregate revenue figures when no direct sources are available.

4. Environmental taxes within the national accounting framework

6.31 National accounts have their own classification of taxes. Three main categories of taxes are distinguished. ***Taxes on production and imports*** cover (a) taxes payable when goods and services are produced or imported (known as ***taxes on products***) and (b) taxes on the ownership or use of assets in production and on the labour employed (known as ***other taxes on production***). Taxes on household income and wealth taxes paid every tax period are described as ***current taxes on income, wealth etc.*** The third category of taxes covers ***capital taxes*,** that is, those levied infrequently and irregularly on the value of assets and those levied on capital transfers.

6.32 Only taxes on production and imports appear within the supply and use framework. In order to incorporate current taxes on capital and on income, wealth etc., it is necessary to expand the supply and use framework towards a full matrix presentation of national accounts by adding the allocation of primary income, secondary distribution of income and capital accounts. A first attempt to categorize environmental taxes with respect to national accounts is given in Table 6.1. (The exact allocation will depend on the precise nature of the taxes.)

Table 6.1. Classification of environmental taxes

Type of tax	Accounting classification
Energy products Imports or sales of vehicles Agricultural inputs (fertilizer, pesticides) Individual products (packaging materials, batteries, tyres, lubricant oils, CFCs, halons etc.)	***Taxes on products***
Measured or estimated emissions to air or water, wastewater discharges, waste Annual vehicle taxes Noise	***Other taxes on production*** when paid by producers ***Other current taxes on income, wealth etc.*** when paid by households as consumers

6.33 Table 6.2 shows the magnitudes of the various taxes in the SEEAland data set and those that can be identified as environmental in nature. Information about the types and levels of taxes applying in OECD member countries can be found via a link on the home page of the Environment Directorate at the OECD web site (www.oecd.org/env/policies/taxes).

Table 6.2. Identifying environmental taxes: an example

Billions of currency units

	Taxes on products			Other taxes on production	Taxes on income		Total
	Environmental protection services	Clean products	Other goods and services		Corporations	Households	
Environmental taxes			3.0	2.0		2.0	7.0
Transport taxes				0.7		2.0	2.7
Levies on noise nuisance				0.2			0.2
Water pollution tax				1.1			1.1
Energy and carbon tax			3.0				3.0
Other taxes and subsidies	0.3	0.1	66.6	2.0	22.5	63.5	155.0
Value-added tax	0.3	0.1	49.3				49.7
Excise duties			16.6				16.6
Import duties			4.5				4.5
Other taxes on production and imports			7.8	4.5			12.3
Other taxes					22.5	63.5	86.0
Subsidies			-11.5	-2.5			-14.0
Total	0.3	0.1	69.6	4.0	22.5	65.5	162.5

Source: SEEAland data set.

C. Property rights and property income

1. Property income

6.34 "Property income" is the term used in the SNA to describe the payment made to the owner of a non-produced or financial asset by a unit that, with the permission of the owner, makes use of the asset in the course of an accounting period. Most property income arises from the use of financial assets and the property income flows are described as interest and dividends. Property income in respect of non-produced assets is described as rent. The concept of economic rent includes the notion of the benefit received by the owner from exploiting the asset himself as well as the payment from another user. This extension, which is not discussed in this chapter, is explored in chapter VII.

6.35 The SNA explicitly mentions only rent on land and rent of subsoil assets for inclusion within the category of rent; but the set of non-produced assets comprises more than just land and subsoil assets. The definition and classification of environmental assets are discussed in sect. 7.B.; but for present purposes it is sufficient to regard the set of naturally occurring entities as the assets of interest.

6.36 Fishing licences are mentioned within the SNA in the context of the fee charged to recreational anglers for engaging in their sport. When the fee is payable to the government, this payment is regarded as a tax. If it was payable to an angling club, say, it would be regarded as a fee for a service. However, there are a few countries, typically island States in the Pacific, that issue fishing licences to permit foreign enterprises to conduct commercial fishing within the exclusive economic zone (EEZ) of the country. When these licences are payable annually and cover the right to fish in those waters only for the year covered, these licences should be regarded as a form of rent also. It is possible to consider permission to extract water from a watercourse in the same way.

Characteristics of rent

6.37 Rent is a current transaction and relates to a payment due within a year for the use of the asset in question for that period only. There may be a lease in existence that guarantees some degree of continuity of permission to use the asset, but the payment itself falls due annually. If the using unit ceases to exist (for example, the farmer dies or an enterprise goes bankrupt), then the lease will normally cease to exist. Even where a lease exists, the level of rent may be subject to a price increase every year or may even be completely renegotiated each year. Payments of rent may depend on the level of output of the user (as in sharecropping, for example). Normally the user of the asset has no entitlement to subcontract the use of the asset. Normally, if there is an annual tax levied on the asset, it is payable by the owner of the asset who may or may not pass this on to the tenant. The cost of the rent will represent a charge on value added and depress the value of the disposable income and saving of the enterprise paying the rent, while increasing the value of disposable income and saving of the owner.

6.38 None of these characteristics is definitive when taken individually but together they give some indication of the characteristics likely to exist when payments for the use of a naturally occurring asset should be treated as rent.

2. Property rights

6.39 The 1993 SNA introduced a new category of assets called non-financial intangible non-produced assets within which there is an item comprising leases and other transferable contracts (see para.10.130). The characteristic feature of intangible non-produced assets is that they entitle their owners to engage in specific activities or produce certain specific goods and services and to exclude other institutional units from doing so except with the permission of the owner. These attributes are what economists refer to as property rights.

6.40 The leases themselves are not produced but rather are legal constructs designed to permit or inhibit certain actions. They may control, for example, who may use a piece of software, who may extract a natural resource and under what conditions, or which sports club avails itself of the services of a particular player.

6.41 Not all leases represent assets. For example, the tenant of a house or apartment is often party to a lease as a document that spells out the responsibilities of the landlord and the tenant and may serve as the basis for settling any disputes between them. Usually, the lease itself will not have an economic value. However, if the rental payable on the house was fixed and the lease entitled the tenant to subcontract his tenancy, and if the rental the tenant could charge exceeded the rental he had to pay the landlord, then the lease would acquire a value.

Acquisition of property rights

6.42 It is important to note the distinction between the right to control use of an asset and the asset itself. In this context, it is only the right of usage that is designated as an intangible non-produced asset. Within the SEEA, we are interested only in property rights in so far as they apply to environmental assets; in practice, these are the same natural assets that can provide property income when put at the disposal of another institutional unit.

6.43 The right to exercise control over an asset may come about by a number of mechanisms. For example:

(a) One way in which an asset comes into being is simply through the recognition of traditional rights. Codification of who has the right to build on or mine which piece of land is one illustration of this;

(b) Environmental assets in common ownership may come to be regulated by government. In effect, government explicitly assumes ownership of the asset and then allocates or sells it to individual users or classes of users;

(c) Government may issue entitlement to use an asset free or may auction or otherwise sell the asset. In terms of numbers, this is the most frequent way in which such property rights are acquired;

(d) Change in prices, together with the initial conditions of a lease, may endow a previous contract with a value. The instance of the lease on a house, quoted above, is an example.

6.44 There is no link between the type of asset subject to an agreement to transfer property rights and the way in which this agreement is arrived at. Fishing quotas are a case in point. They may be acquired by recognition of traditional rights, they may be allocated by government either free or at an arbitrary figure, or they may be bought and sold via a market. A fisherman who acquires his quota through either of the first two mechanisms and then discovers the market price is higher may be able to sell his quota to a third party, as in the case of a house lease.

Characteristics of property rights

6.45 A property right constitutes an intangible non-produced asset only if the right to use the asset is (or was) conveyed for a period exceeding one year. Sometimes the right of use will be indefinite. Almost certainly, some legal documentation will exist to evidence control over the property right. If the agreement is for a year only, even if it is renewable, then this agreement is commonly called a licence and the payment due under it is treated as rent, as described above. It should be noted, though, that it is the period of the agreement, and not the use of the word "licence" alone, that determines whether the payment constitutes rent or acquisition of an intangible asset.

6.46 Where property rights are acquired by purchase, the total cost will be negotiated at the outset. This cost is seldom subject to adjustment or renegotiation during the period of its validity. The transactions for the sale and acquisition of property rights are recorded as capital transactions and do not affect the saving of either the asset owner or the user. If the cost is not met in full at the time the property right passes from the (original) owner to the new owner/user, the difference will be recorded in terms of financial assets and liabilities with respect to the two parties.

6.47 The right to use the asset may itself be separately saleable or, at least, transferable to a new owner of the unit holding the property right. (In many cases, the property right may be the most important feature of the unit.) If a tax on the right to use the asset is levied, it is likely that the user will be responsible for paying it.

6.48 As before, none of these characteristics is definitive but together they give an indication of the likely terms existing when payment for the use of a naturally occurring asset is to be treated as the acquisition of an intangible non-produced asset (property right).

Examples of environmental property rights

Fishing rights

6.49 Historically, no ownership rights were established over fish in the deep oceans. This has led to reduction of fish stocks to dangerously low levels in some instances. While it is impossible to designate ownership over such fish, it is possible to limit the amount of fish that may be legally caught by an individual, an enterprise or a country. Such quotas are agreed by national and international agreement.

6.50 Usually a quota is assigned on the basis of historical catches. If someone who is awarded such a quota wishes to leave fishing, he may usually sell his quota to someone else. Because of the shortage of quotas, a market in fishing licences may quickly develop.

6.51 When quotas are agreed for a period of time (or indefinitely), they represent the acquisition of an intangible non-produced asset. One of the beneficiaries may be governments when, by international agreement, the wild stocks of particular fish species in the open oceans are allocated among a number of nations.

6.52 The question of placing a valuation on fishing quotas, discussed in detail in chapter VIII, depends crucially on the determination of the resource rent of the quantity and nature of the fish covered by the quota. Briefly, when fishing quotas are freely bought and sold on an open market, the market price of the quota is the value that the SNA ascribes to the quota. In a well-functioning market, this value will represent the net present value of the expected future resource rent of the catch. When there is no market in quotas, it may be appropriate to place a value on the quota by estimating this discounted value of the future resource rents.

Emissions permits

6.53 Emissions permits designate the quantity of specific emissions, for example, greenhouse gases, that may be generated before a penalty payment is triggered. As with fishing rights, the quantity of emission permitted is often based on historical patterns. Such permits may be used simply as regulatory mechanisms; but, more realistically, by allowing the permits to be traded, and in particular to be traded internationally, they provide an incentive for a producer to reduce his emissions so that he may realize the value of the emissions permit by selling or leasing it.

Accounting entries for tradable permits

6.54 When a tradable permit is issued, the unit issuing the permits (almost always government) creates the asset and records this creation in its other changes in assets account. If the permit is sold (perhaps by auction or at a predetermined price), then the sale and purchase are recorded in the capital accounts of the two units involved. If it is issued free, but has a positive value – determined, for example, on markets or through net present value calculations – it is still recorded in the same way as sale and purchase in the capital account, but in addition a capital transfer of the same size is made from the issuer to the new owner of the permit. This transfer exactly cancels the acquisition of the permit, hence the lending or borrowing position of each of the two units is unaffected.

6.55 Tradable permits may be of infinite duration or for a fixed period. The value of a tradable permit is determined in the market but it is assumed that the value is consistent with a net present value representing the value of the permit for each of the years for which it is valid, suitably discounted. If the life length of the permit is fixed, as each year passes, the market value will decrease, reflecting the approach of the expiry date. This decrease in the value of the tradable permit is recorded as disappearance of an intangible non-produced asset in the other changes in assets account.

6.56 For as long as they are valid, permits may be traded and any actual trading is recorded, as before, in the capital account. The market value of permits may rise and fall in response to changing supply-and-demand patterns, giving rise to holding gains and losses on the permits. These holding gains and losses are recorded in the revaluation part of the other changes in assets account.

6.57 The introduction of tradable permits aims to limit the production that gives rise to environmental damage by means of legislation that is implemented via a capital market mechanism. While the existence of tradable permits is expected to influence production behaviour, it does not show up in the production account but rather in other SNA accounts dealing with the acquisition of assets. Even when an annual licence is issued for the use of environmental assets, it would feature in the production account only if it were classified as a tax on production. However, since, as indicated above, this is unlikely, it will be recorded instead as a payment of rent in the distribution of primary income account.

D. Environmental consequences of disposing of fixed capital

1. The problem

6.58 It is necessary to consider not just the impact on the environment as production occurs but also what costs are incurred to prevent environmental problems when production or operation ceases – when, to mention a few typical examples:

(a) Nuclear power plants must be decommissioned and final storage of nuclear waste must be provided;

(b) Oil rigs and other mining equipment must be dismantled and removed;

(c) Landfills must be sealed, gas and leakage collection systems completed, and supervision equipment installed.

6.59 These may be referred to briefly as ***terminal costs***, that is, costs that can and should be anticipated during the production periods prior to closure. Provision should be made to meet them during the life of the asset. Another type, which we may categorize as ***remedial costs***, are incurred when production has already ceased with no provision having been made while production was in progress for the taking of remedial action. Examples are the rehabilitation of sites contaminated by past activities, for example, fuel storage sites, and former landfill and mining sites.

6.60 As these costs are associated with measuring the use of produced capital in the SNA, it would be useful to first review the concept of consumption of fixed capital and how it should be recorded.

2. Consumption of fixed capital

6.61 The using up of man-made capital is taken into account in a production account by means of an allowance for consumption of fixed capital. This is usually referred to by commercial accountants as depreciation and perceived to be the writing off of the original costs of the assets involved over their useful life. More properly though, the consumption of fixed capital shows the decrease in the net present value (NPV) of the future income stream to be expected from the use of the asset, a figure that should be deducted from income and converted to another form of capital if the capital base is to remain intact.

6.62 The economic assumption is that the cost of purchasing the asset, either new or at any period of its useful life, is equal to the NPV. If the asset costs more than the NPV, it would not be a good investment; if the NPV exceeds the asset price, the seller of the asset could ask for more. It is often assumed that, in the absence of inflation, the cumulated value of the consumption of fixed capital must be equal to the original purchase price of the asset. However, it does not necessarily follow that the original purchaser will benefit from the whole of the NPV. For example, hire cars may be sold to individuals or aeroplanes to a foreign airline after only a few years of service. The original purchasers keep their capital intact by allowing for the decline in value only between the point of acquisition and time of disposal of the asset. To include the whole of the value would be to overstate the deduction from income and understate national income.

6.63 Even making the calculation for consumption of fixed capital does not ensure that capital is kept intact. It would be, however, if the sum for consumption of fixed capital were immediately reinvested or even if it were set aside as a financial asset against the day when the asset would eventually be replaced. However, the owner of the asset may decide to spend the amount of consumption of fixed capital *as if* it were current income. In the SNA, this expenditure would be recorded as current expenditure, resulting, however, in a decline in net worth. It is important to recognize that the correct valuation of consumption of fixed capital does not depend on the creation of a "sinking fund" for the eventual replacement of the asset. It is simply a calculation of what proportion of receipts must be excluded from a measure of income to permit the *possible* maintenance of capital intact.

3. Terminal costs

6.64 Consider two prototypic examples. Power plants and oil rigs are assets most of whose environmental protection costs are actually incurred at the end of their useful life as some sort of decommissioning activity. In contrast, landfill sites entail costs that may be ongoing throughout their use besides continuing when that use terminates.

Power plants and oil rigs

6.65 Discussed above was the case where an asset such as a car or an aeroplane was sold before the end of its useful life so that the cumulated value of consumption of fixed capital would be less than the purchase price. For some assets, instead of a positive disposal value, there will be actual disposal costs, constituting a sort of negative disposal value. If such items are disposed of and the owning enterprise continues in business, these costs will be deducted from income, possibly by including them as part of intermediate consumption. There is a question whether this is a conceptually correct recording, as well as the issue of what happens if the asset is disposed of and the costs incurred only at the end of the life of the owning enterprise when there is no income against which to set these costs.

6.66 It was stated above that the NPV of the expected earnings from the deployment of an asset on acquisition should be at least as great as the purchase price in order to make the purchase cost-effective. When a hire car is purchased, the sum of the disposal value plus the NPV of the expected earnings must together equal the acquisition price. If it is known in advance that there will be significant disposal costs, the expected earning capacity of the asset must be great enough to cover both the acquisition price and the disposal cost if the purchase is to be cost-effective.

6.67 The value of an asset at any point in time should be determined by discounting the income to come in future years. If instead of income, there are costs to be incurred in future, these also should be built into the value of the asset, discounted as for income. Any potential buyer of the asset would have to factor the disposal costs as well as the earning potential of the asset into his decision regarding whether to buy and, if so, then the price to offer. The prospect of disposal costs affects the value of the asset throughout its life. Consumption of fixed capital should still be calculated as the change in the value of the asset between the start and the end of the accounting period but this will now take account of the disposal costs as well as the income earning capacity of the asset. Just before the end of its life, the asset will have a negative value, showing that it actually represents a liability to the enterprise that is about to face the disposal costs. The disposal costs should be recorded as capital formation when they are actually incurred but the deduction of these costs from income via consumption of fixed capital will have been made progressively over the life of the asset, as is the case for the "replacement costs". If the enterprise has indeed set aside a "sinking fund" with the sums calculated as consumption of fixed capital, then this amount will be great enough to offset the disposal costs. At that point, even a firm going out of business will have a financial asset being converted to capital formation to bring the total capital value for the produced asset back to be exactly zero.

6.68 Ignoring inflation for simplicity's sake, the basis of the calculation of consumption of fixed capital should be such that its cumulated value over the asset life length is exactly equal to the initial cost of the asset less any disposal value plus any decommissioning costs. This is a general statement and applies to the case where an asset is disposed of early (with a positive value), and to the normal case where there is neither a disposal value nor a cost, as well as to the case of interest here.

6.69 If the decommissioning activity also includes improvement of the production site or restitution to its condition prior to the start of production, this part counts as fixed capital in the form (usually) of land improvement. In this case, though, the fixed capital has been paid for in advance of its being put in place rather than afterwards. The cumulative value of the consumption of fixed capital during the life of the production site has covered the costs of both the acquisition of the assets at the beginning (or during) production and decommissioning when production ceases.

6.70 No new financial asset needs to be created for the "sinking fund". It will be part of the enterprise's portfolio of financial assets, although its purpose might be earmarked in advance.

Practical recommendations

6.71 Nuclear agencies increasingly put aside part of their revenue to cover both decommissioning costs and storage of nuclear waste. Sometimes, the size of these provisions may be determined not within the industry by consideration of the life length of the plant and present expected decommissioning cost but by legislation. Whatever the basis for calculating the provision, when the size of such provision is known, and if it is certain that the consumption of fixed capital estimates for the industry made for the national accounts do not take terminal costs into account, it is appropriate to add the amount of the annual provisions to the existing consumption of fixed capital estimates.

6.72 Although national accountants regularly revise many of the data series they work with, they seldom revise estimates of consumption of fixed capital except for the effect of price changes. Given that the expected useful life length of the asset may change, say, because a newer technological model has become available, in principle the estimates of consumption of fixed capital should change to reflect the new situation. Changes in the amount of provisions (or costs of) decommissioning should be taken into account in the same way. Since, in practice, this may not happen, one of the following approximations may have to be used.

6.73 Even when estimates for decommissioning costs have been made during the life of the asset, it may prove that these estimates do not exactly match the actual costs. In such cases (or when no allowance has been made at all), there are two alternatives open for recording this adjustment in the accounts. The first is to record the costs as positive capital formation (viewing this as improvement to the site of the asset to be decommissioned) with an immediate write-off in consumption of fixed capital. Immediate write-off of capital expenditure is not normally advocated in the SNA but, in this case, it could be regarded as a form of correction to the accounts that avoids retrospective adjustment to the time series of consumption of fixed capital over the asset's life.

6.74 The alternative suggestion is to treat the decommissioning costs as intermediate consumption. In this case, the effect on net national income will be the same as that indicated above, but the pattern of input coefficients in an input-output table would be radically changed and any calculations involving productivity studies will be distorted. If the enterprise is decommissioning equipment just prior to going out of business, this approach may be realistic; however, when the business continues, it is less desirable.

6.75 Both alternatives are means of keeping the value of net worth after decommissioning correct but both entail the fact that some costs that should conceptually have been set against a measure of income where capital is kept intact have been ignored. As long as users of national accounts continue to concentrate on gross measures of production rather than on income, this will not be a significant concern for them.

Landfill sites

6.76 Landfill sites may be designated in order to reclaim land, either from the sea or from the state in which it was left by previous economic activities such as quarrying for construction materials. The reclaimed land has an economic value in excess of that of the site before reclamation but this may be at the expense of environmental damage due to leaching of toxins into surrounding land, water and air. Other landfill sites may originate as greenfield sites in which case the economic value is likely to decrease during use and may recover their original value only by purposive restoration. Here, too, environmental damage may be associated with the use of the site, unless specific measures are taken.

6.77 One of the consequences of leaching from waste sites is that the damage may be felt, and recorded, by other economic activities. For example, leaching of chemicals may reach an aquifer used for water supply into agricultural land and thus reduce crop yield. In a more tolerant age, this was often regarded as just the farmer's bad luck. Increasingly, compensation for the farmer from the waste site operator is sought.

6.78 When landfill sites are legally authorized, the active control and operation of the site form part of economic activity as conventionally measured. In the case of illegal, unauthorized dumping, there is no associated economic activity in respect of operating the landfill site to be measured. (It may lead to increases in other costs incurred by the owner of the land used or, in the case of roadside dumping, by the public authorities.) The environmental implications are the same as those for abandoned (legal) landfill and mining sites and are discussed below in the section on remedial costs.

6.79 The operation of some landfill sites may be such that environmental damage is either inhibited or reduced on a continuing basis during the time the site is being used for dumping waste. If so, the associated costs should be identified as environmental protection directly. Sometimes, there may be provisions in place to restore the site once it is no longer to be used for depositing waste. In this case, the procedures to be used are similar to those described above for power plants and oil rigs. Increasingly, the value to be placed on terminal costs is known from legislation that prescribes the clean-up activities to be carried out. Note that these costs may not restore the full environmental capacity of the land, for example, to that of good agricultural land, but may simply ensure that it is environmentally safe.

6.80 When land reclamation is the motivation behind the operation of a landfill site, part of the output of the activity represents fixed capital formation as land improvement. The value of the output will be represented by the increase in the market value put on the resulting reclaimed land. Note the importance for this valuation of ensuring that any remaining environmental damages are known and estimated.

Practical recommendation

6.81 As in the case for power plants and oil rigs, the most practical solution for making estimates for the terminal costs for landfill sites may be to use the costs prescribed by legislation on mandatory clean-up.

4. Remedial costs

6.82 The situation is different when remedial action is necessary after – sometimes long after – a landfill site has been closed and the original operator has left. For completeness, we include illegal dumping sites here also. Two aspects need consideration. The first is the restoration of the land area to enable it to be used for some other purpose. (This is relevant in the case where the site was originally a greenfield one, since, otherwise, the motivation for the activity of the land reclamation is presumed to be restorative in character.) The second involves ensuring that no harmful emissions from past waste deposits leach into the surroundings, thereby causing environmental damage.

6.83 The accounting treatment of land restoration is straightforward. The costs of the restoration are treated as land improvement and are included in fixed capital formation. This is the situation in the national accounts and no additional estimates should be needed for the SEEA. In the balance sheet, the value of the land improvement is aggregated with the value of the underlying land value (a non-produced asset) and no longer separately distinguished. If the improved land provides a service in perpetuity either as land under buildings or as agricultural or recreational land that does not degrade, then there may be no consumption of fixed capital to take into account. If there is degradation, the issues of putting a monetary value on this degradation are the same as those for degradation of land in general.

5. Summary

6.84 The 1993 SNA does not discuss specifically how to treat decommissioning costs or the treatment of managed landfill sites. What follows are recommendations based on an interpretation of the SNA. The recommendations are consistent with the capital services approach to measuring capital stock which has been declared to be consistent with the SNA by various experts and incorporated in recent manuals published by OECD on the measurement of capital stock and productivity (OECD, 2001a and 2001b). Nevertheless, it should be clearly stated that at present this is not common practice for estimating consumption of fixed capital in the SNA context. The matter has not been widely discussed in national accounting circles though perhaps it should be, since a good measure of income on a net basis presumes that all appropriate costs of maintaining produced capital intact have been taken into account. If and when such a discussion leads to a formal clarification of the SNA position on terminal costs, then this section of the SEEA should be reviewed. In the meantime, the following summary of the conceptually correct way of handling these issued is put forward.

6.85 The total value of capital formation to be recorded for an asset over the whole of its life is the cost at acquisition, less any receipts from its sale, plus any terminal or decommissioning costs. Each of these is recorded when it actually takes place.

6.86 The sum of these entries (adjusted as necessary for inflation) shows the amount that the enterprise owning the asset has to account for as consumption of fixed capital over the life of the asset.

6.87 If decommissioning costs are not taken into account, consumption of fixed capital will be too low, and net operating surplus and (net) national income will be too high.

6.88 At any point in time, the sum of the original value of the asset less the present value of any receipts expected on disposal, plus any terminal costs, should exactly equal the sum of the residual value of the asset plus the cumulated consumption of fixed capital (assuming all entries are properly adjusted for inflation). The simplest case to consider is an asset that has no disposal value and no terminal costs. At the start of the asset's life, the whole value is embodied in the asset and the consumption of fixed capital is zero. At the end of the life, the value embodied in the asset is zero and the cumulative value of consumption of fixed capital is equal to the original value of the asset. At any intermediate point, both the value embodied in the asset and the cumulative consumption of fixed capital to date will have changed but the total will remain constant (always assuming no inflation.)

6.89 At the end of a produced asset's life, the residual value in the balance sheet should be exactly zero. This means one of the following situations should obtain:

(a) The asset no longer exists, for example, an oil rig has been dismantled and sold as scrap;

(b) The asset exists but no longer presents risk of damage in future, for example, a nuclear power station has been safely decommissioned;

(c) Land used in production should have been returned to its original state, for example, landfill sites and mines should have been reclaimed. The value of the terminal costs, recorded as fixed capital formation, represents the cost of so "improving" the assets as to enable them to achieve a desired state.

6.90 If no estimates of terminal costs have been made during the life of the asset, they can be recorded when they occur as either capital formation and instant write-off via consumption of fixed capital or as intermediate consumption. Users should be alerted to the impact of these pragmatic solutions on the path of investment, and on the pattern of asset values, and the consequences for technological and productivity studies.

E. Locating economic instruments within the SNA

1. Tabulating redistributive processes

6.91 In order to see where the economic instruments described above appear in the national accounts, it is necessary to first recapitulate the essential features of the income and capital accounts of the SNA. What follows is much abbreviated and simplifies some of the details of the SNA as an aid to clarity for those not intimately familiar with the finer points of the system. Readers wanting further information should refer to the 1993 SNA or consult someone working in the national accounts area.

6.92 For simplicity, we consider only three groups of units within the national economy. All production is carried out by enterprises. Households are consumers only. Government acts as a redistributor of funds, inter alia, through the provision of public services. (For simplicity's sake, we include the production activities of government with enterprises so that we may concentrate on the redistributive nature of government actions.) In addition, we must consider the rest of the world insofar as it interacts with the national economy.

6.93 The supply and use tables or input-output tables show a figure for value added which is the starting point for the subsequent accounts. The first of these is the ***generation of income account*** which shows how value added is used to pay taxes on production, compensation of employees and consumption of fixed capital. Though this is not exactly how the SNA shows taxes on products, it is simplest, for the representation that we are considering here, to show taxes on products in this account also. Some environmental taxes appear in this account under both tax headings. These may be paid by enterprise and households and are received by government. In addition, there may be tax transactions with the government and residents of another country via the rest of the world account. Any subsidies paid by government relating to production are also shown in this account. By convention, they are shown on the same side of the account as taxes but with the opposite sign, that is, as negative payables instead of positive receivables and vice versa. Any value added not accounted for by one of the other items in the account is designated net operating surplus.

6.94 The ***distribution of primary income account*** shows how net operating surplus, compensation of employees and taxes on products and production are augmented by the receipts and depleted by the payments of property income. Within property income, we wish to distinguish rent on land and rent on other natural assets. These may be paid and received by any of the three groups of national units. Because of the SNA conventions on residence, there will be no such payments involving the rest of the world: any such transaction are always routed through a national unit even if a de facto unit must be set up to ensure this. The balancing item on this account is the balance of primary incomes.

6.95 The ***secondary distribution of income account*** covers payments and receipts of all sorts of transfers. These include payments of income tax, and social insurance contributions and benefits as well as private transfers. The account is very important in explaining how redistribution of income occurs but has few entries relating to the environment. However, any transfers made to, say, environmental pressure groups or those undertaking environmental protection on a non-profit basis will appear here. The resulting balancing item on this account is the disposable income of the group of units concerned. In the following account, the ***use of income account***, this is either used to satisfy consumption needs or saved. Among consumption needs will be those purchases of environmental services and environmental goods discussed in chapter V.

6.96 Saving is either used for investment purposes or redeployed through financing borrowing and lending. The details of the ***capital account*** are discussed in chapter VII and here it is sufficient to note that this account contains details of acquisition and disposals of land and property rights and also shows capital expenditure related to environmental protection, mineral exploration, land improvement, major environmental protection projects as well as to the net increase of cultivated plants and animals.

6.97 Table 6.3 is a schematic presentation of these accounts. Not all groups of units are involved in all transactions. For example, only enterprises and government are charged with consumption of fixed capital. For some transactions, one group of units make payments and another receive payment. For example, enterprises and households pay taxes; government receives them. Only enterprises and the rest of the world pay dividends but all groups of units, including (other) enterprises, may receive them.

Table 6.3. Schematic presentation of income and capital accounts

		Enterprises		Government		Households		Rest of the world		Total
		Payable	Receivable	Payable	Receivable	Payable	Receivable	Payable	Receivable	
	Imports/Exports							-	+	+ -
Generation of income account	*Value added*		+							+
	Environmental taxes on products	-			+	-				
	Other taxes on products	-			+	-				
	Other taxes on production: environmental	-			+	-				
	Subsidies on production: environmental	+			-					
	Other taxes on production: non environmental	-			+	-				
	Subsidies on production: non-environmental	+			-					
	Compensation of employees	-		-			+	-	+	
	Consumption of fixed capital	-		-						
	Net operating surplus	-								-
Distribution of primary income account	*Net operating surplus*		+							+
	Rent on land	-	+	-	+	-	+			
	Rent on other natural assets	-			+					
	Interest	-	+	-	+	-	+	-	+	
	Dividends	-	+		+		+	-	+	
	Balance of primary income	-		-		-				-
Secondary distribution of income account	*Balance of primary income*		+		+		+			+
	Taxes on income, wealth etc.	-			+	-		-	+	
	Transfers to environmental organizations	-	+	-		-				
	Other current transfers	-	+	-	+	-	+	-	+	
	Disposable income	-		-		-				-
Use of income account	*Disposable income*		+		+		+			+
	Consumption of environmental services			-		-				-
	Other final consumption			-		-				-
	Saving/balance on current account	-		-		-		-		-
Capital account	*Saving/balance on current account*		+		+		+		+	+
	Capital formation: mineral exploration	-								-
	Capital formation: land improvement	-								-
	Capital formation: net increase in cultivated biological resources	-								-
	Other capital formation	-								-
	Acquisition less disposal of property rights	-			+					
	Acquisition less disposal of land	-	+	-	+	-	+			
	Capital transfers	-	+	-	+	-	+	-	+	
	Net lending or borrowing	-		-		-		-		-

6.98 The right-most column of Table 6.3 shows the total for each transaction across the whole economy. For many of the items, there is no entry. This is because many of the items are redistributive in nature and so total payments must be equal to total receipts. In addition, since the balancing items of the account appear first as a payable in one account and then as a receivable in the next, these also cancel. Non-cancelling items in the total column are shaded and illustrate a familiar identity. Imports less exports plus value added equals final consumption plus capital formation. It is because the income and capital accounts reduce on consolidation to this GDP identity that, for some analyses of economic activity, supply and use tables are sufficient. However, as is clear from the bold entries and as a result of our interest in environmental transactions, we need to investigate the income and capital accounts if we wish to have a complete picture not just of the interaction between the economy and the environment but also of the role played by the different units in the economy.

2. Portraying redistribution in a matrix form

6.99 Just as the goods and services account, that is, the basic GDP identity just quoted, can be expanded into a very useful matrix form via the supply and use tables, so the other accounts can be expanded into a matrix presentation also. When only national accounts elements are considered, the result is a social accounting matrix (SAM), as explained in chapter XX of the 1993 SNA; but here, too, a hybrid version can be established by adding physical information on the use of natural resources and ecosystem inputs and on residuals generated. This hybrid SAM is also a NAMEA – in fact, it is a much fuller representation of one than the versions considered in chapter IV.

6.100 One of the reasons that national accounts tables are sometimes difficult to understand is that they try to portray a three-dimensional table on a two-dimensional piece of paper. In almost all cases, the information to be conveyed is what sort of transaction is being considered, and who pays and who receives. It is possible to show for any given transaction, who pays and who receives, and for any recipient, which transactions are made by which payers or, conversely, for any payer, which transactions are made by which recipients. The simplest tables, but least informative, are those that give a list of transactions but with no information on either payers or receivers. Of course, what often happens in practice is that a table of many transactions is given with a heading that states the payer and receiver (if relevant) and the list of transactions is repeated for different headings.

6.101 The supply and use tables presented in chapters III and IV conform to this scenario. In the supply table, a list of products is given for the industries that make them, that is, the "what" and "from whom" are detailed but not the "to whom". The use table shows "what" and "to whom" but not "from whom". As long as products and industries use different classifications, these two tables cannot be combined in a single two-dimensional table. An input-output table can be seen as a means of avoiding the third dimension by mapping the product and industry classifications into one another.

6.102 Consider the row for other current transfers from Table 6.3. This shows there are four possible (groups of) payers and four possible recipients. A full articulation of transfers would involve a four-by-four matrix with 16 entries to replace the 8 in Table 6.3. What Table 6.3 actually shows is the row and column totals of the full four-by-four matrix; or, if we included row and column totals of the four-by-four matrix and made it a five-by-five matrix, it would be these totals that appear in Table 6.3.

6.103 Table 6.4 gives an example of how to expand a simplified version of the secondary distribution of income account. For simplicity's sake, it is assumed there are no transactions with the rest of the world. As with the earlier matrix presentations, for each account, receipts are entered along a row and payments are entered down the matching column. The complete matrix of which this is a part appears as a chequerboard with squares on the diagonal representing each of the rows in Table 6.3 expanded to show all the payers and receivers and balancing items in the elements just below the diagonal.

6.104 The top left hand block of the table shows the entries for the balance of primary incomes for the three groups of units in the national economy. This block appears at the intersection of the columns for the distribution of primary income account and the rows for the secondary distribution of income account.

Table 6.4. Illustration of a secondary distribution of income account in matrix form

		Distribution of primary income account			Secondary distribution of income account		
		Enterprises	Government	Households	Enterprises	Government	Households
Secondary distribution of income account	Enterprises	Balance of primary income					Other current transfers to enterprises from households
	Government		Balance of primary income		Taxes on income to government from enterprises *plus* other current transfers to government from enterprises		Taxes on income to government from households *plus* other current transfers to government from households
	Households			Balance of primary income		Other current transfers to households from government	
Use of income account	Enterprises				Disposable income		
	Government					Disposable income	
	Households						Disposable income

6.105 The top right block of entries shows the transactions for the secondary distribution of income and appears on the main diagonal of a full SAM. The items in the bottom right block of the table are the balancing items for this account, disposable income. Since, as its name implies, the secondary distribution of income account is redistributive in nature, and since, in this case, there are no entries for the rest of the world, total disposable income has the same total value as the balance of primary income. The significance of the elaboration is that the distribution of the same amount of income is different after secondary redistribution has taken place. This block, like that for the previous balancing item, the balance of primary income, appears below the diagonal where the rows and columns for two adjacent accounts intersect.

6.106 Two observations can be derived from comparing Table 6.4 and Table 6.3. Because the transactions involving taxes are restricted to only one unit – government, which is the receiver – the matrix format does not add much information in this case. On the other hand, for transfers (and this would be the case if we had included taxes paid to and by the rest of the world), the matrix format allows much greater detail to be specified. The cost is a quite considerable increase in the physical size of the table. Further, when a SAM is actually compiled in practice, the words in the entries are omitted and the user is required to remember what sort of transactions occurs at each of the intersections. Nor are the time-series aspects of the system obvious from what is essentially a cross-sectional presentation. For these reasons, a matrix presentation is often used to explain or illustrate some of the interrelationships of a full system but the actual detailed tables are still presented as expansions of individual parts of the full matrix in normal two-way tables. However, conceptualizing the system in matrix format is a powerful way of investigating other dimensions of the accounts and deploying the flexibility inherent in the system, as the following examples illustrate.

3. Exploiting the potential of a matrix formulation of the accounts

6.107 Table 6.5 shows a schematic version of a matrix presentation of the supply and use tables augmented by the complete sequence of accounts of the SNA together with the physical data on natural resource and ecosystem inputs and residual outputs. The largest section, which covers the national economy, has the block diagonal appearance described above in discussing the expansion of the secondary distribution of income account. To the right and below are two borders, the first covering the transactions with the rest of the world economies, and the second flows to and from both the national environment and the rest of the world.

6.108 In this format, the role of the interactions between the national economy and the rest of the world is immediately clear. For most developed countries the flows apart from those imports and exports, though important, tend to be relatively small compared with the flows within the national economy. For less developed countries, though, this may not be the case: visible at a glance, the importance of inflows of migrants' earnings via transfers from abroad or debt interest payments in property income due abroad may vividly reflect the country's dependence on the international economy.

6.109 The first two rows and columns of Table 6.5 correspond to the hybrid supply and use table in Figure 4.1, though there has been some compaction simply for reasons of space. The entries for trade and transport margins and for taxes less subsidies on products are omitted from the first column. The residuals generated by consumption and capital formation are combined in one row. Later elaborations of the accounts for consumption and capital formation show how these residuals can be associated with the activity generating them.

Environmental taxes

6.110 Table 6.5 does not show any entries for taxes explicitly. In order to make these explicit, some further manipulation of the table is necessary. If our interest is in looking at all types of taxes so that we may identify the impact of environmental taxes through the matrix, it is helpful to add a row and matching column for total taxes. This row and column are filled by so partitioning other flows as to separate the tax element from the rest (see Table 6.6).

6.111 The first step is to add an explicit entry for the taxes on products and imports which must be added to the value of goods and services (row tax, column 1) to bring these up to market prices. Row and column 2 are then partitioned to show the generation of income account separately from the production account. The new row and column 2a correspond to the previous production account at basic prices, giving a balancing item of value added at basic prices. In row and column 2b, other taxes on production are separated out from value added and shown as a payment in the row for taxes and a receipt in the tax column. (The point of this is better seen when there is further disaggregation showing that it is enterprises that pay the tax and government that receives it.) In fact, the receipts of taxes on products including taxes on imports are shown in the same entry in the column for tax receipts.

Table 6.5. A hybrid national accounts matrix

			National economy									
			Goods and services (products)	Production (industries)	Distribution of primary income account	Secondary distribution of income account	Use of income account	Capital account	Financial account	Rest of the world	National environment	Rest of the world environment
			1	2	3	4	5	6	7	8	9	11
National economy	Goods and services (products)	1		Intermediate consumption			Final consumption	Capital formation		Exports		
	Production (industries)	2	Output								Residuals from production	Residuals from production
	Other residual generation										Residuals from consumption and capital formation	Residuals from consumption and capital formation
	Distribution of primary income account	3		Value added	Property income					Primary income flows from the ROW		
	Secondary distribution of income account	4			Balance of primary income	Current transfers				Current transfers from the ROW		
	Use of income account	5				Disposable income						
	Capital account	6					Saving	Capital transfers		Capital transfers from the ROW		
	Financial account	7						Net lending or borrowing	Acquisition and disposal of financial assets			
	Rest of the world	8	Imports		Primary income flows to the ROW	Current transfers to the ROW		Capital transfers to the ROW	Net lending to or borrowing from the ROW		Residuals from the ROW economy	
	National environment	9		Environmental inputs to production			Environmental inputs to consumption			Environmental inputs to ROW economy		
	Residuals	10		Residuals reabsorbed by production				Waste going to landfill sites				Cross-boundary residual outflows
	Rest of the world environment	11		Environmental inputs to production			Environmental inputs to consumption				Cross-boundary residual inflows	

6.112 The next step is to separate out that part of current transfers that represent payments and receipts of current taxes on income, wealth etc. The payments are moved down to the row for tax payments; the receipts are moved right, to the column for tax receipts. Again, this exercise is more interesting when the payments are divided between enterprises and households and the receipts shown accruing to government. A similar exercise could be carried out to separate capital taxes from other capital transfers, though this is not effected in Table 6.6. The extension of these manipulations to distinguish those taxes deemed to be environmental in nature is straightforward.

Table 6.6. Introducing taxes in the matrix

			National economy									
			Goods and services (products)	Production (industries)	Generation of income account	Distribution of primary income account	Secondary distribution of income account	Use of income account	Capital account	Financial account	Rest of the world	Tax receipts
			1	2a	2b	3	4	5	6	7	8	Tax
National economy	Goods and services (products)	1		Intermediate consumption				Final consumption	Capital formation		Exports	
National economy	Production (industries)	2a	Output									
National economy	Generation of income account	2b		Value added at basic prices								Taxes on products, imports and production
National economy	Distribution of primary income account	3			Value added at market prices	Property income					Primary income flows from the ROW	
National economy	Secondary distribution of income account	4				Balance of primary income	Current transfers other than taxes on income, wealth etc.				Current transfers from the ROW	Taxes on income, wealth etc.
National economy	Use of income account	5					Disposable income					
National economy	Capital account	6						Saving	Capital transfers		Capital transfers from the ROW	
National economy	Financial account	7							Net lending or borrowing	Acquisition and disposal of financial assets		
	Rest of the world	8	Imports			Primary income flows to the ROW	Current transfers to the ROW		Capital transfers to the ROW	Net lending to or borrowing from the ROW		
	Tax payments	Tax	Taxes on products and imports		Other taxes on production		Taxes on income, wealth etc.					

6.113 Chapter IV described how an input-output table can be used to derive the total import content or total environmental content of a given pattern of final demand. Once a table such as Table 6.6 has been completed, a new input-output table can be derived and the same processes used to derive direct and indirect effects of taxes on final demand.

Disaggregating households and household consumption

6.114 As noted, in practice, the rows and columns for the income accounts (numbers 3-7) are disaggregated to show the various groups of units concerned (broadly speaking, institutional sectors, in SNA terminology) including identifying households where appropriate. One of the main motivations for the construction of a SAM is to be able to focus attention on households, their income and consumption, quite as much as on production. Many SAMs therefore disaggregate households by type of household, often by income level. This means that different pairs of rows and columns show the income and expenditure patterns of high-, middle- and low-income families, for example.

6.115 However, one can also use this device to introduce not only new rows and columns so as to disaggregate a previous heading, but also a new classification. In the case of the environment, we may well wish to distinguish the reasons for which consumption is undertaken and not just the products purchased. This means that we may group, under a heading for transport, all expenditure on public transport and the costs of running a private car. If we disaggregate the original column where consumption for all households was shown in order to display the cross-classification of products bought and their function or purpose (according, let us say, to COICOP) then we must introduce the same number of corresponding rows. In each of these rows, we can identify the expenditure for a given purpose and the residuals generated also classified according to purpose or function. This allows us to combine residuals coming from food consumed at home and in a restaurant and to make a distinction between residuals coming from paper products used for hygiene and cleaning (kitchen towels, for example) and those used for entertainment (books and newspapers, for example). An example of how this functional classification can be introduced is given in Table 6.7. It is, of course, possible to carry out successive disaggregations so that, for example, households can be disaggregated by income level as well as by consumption expenditure by purpose. The only limits to the number of disaggregations that can be incorporated are those imposed by the capacity of the imagination to construct interrelated disaggregations, by data limitations and by the size of the page on which the matrix is to be presented.

Table 6.7. Disaggregating household consumption: an example

				National economy										
				Goods and services (products)	Production (industries)	Distribution of primary income account	Secondary distribution of income account	Use of income account		Capital account	Financial account	Rest of the world	National environment	ROW environment
								Inputs to functions	Total use					
				1	2	3	4	5a	5b	6	7	8	9	11
National economy	Goods and services (products)		1		Intermediate consumption			Purchases by consumers		Capital formation		Exports		
	Production (industries)		2	Output									Residuals from production	Residuals from production
	Other residual generation												Residuals from capital formation	Residuals from capital formation
	Distribution of primary income account		3		Value added	Property income						Primary income flows from the ROW		
	Secondary distribution of income account		4			Balance of primary income	Current transfers					Current transfers from the ROW		
	Use of income account	Outputs of functions	5a						Final consumption				Residuals from consumption	Residuals from consumption
		Total use	5b				Disposable income							
	Capital account		6						Saving	Capital transfers		Capital transfers from the ROW		
	Financial account		7							Net lending or borrowing	Acquisition and disposal of financial assets			
	Rest of the world		8	Imports		Primary income flows to the ROW	Current transfers to the ROW			Capital transfers to the ROW	Net lending to or borrowing from the		Residuals generated by non-residents	
	National environment		9		Environmental inputs to production			Environmental inputs to consumption				Environmental inputs to the ROW economy		
	Residuals		10		Residuals reabsorbed by production					Waste going to landfill sites				Cross-boundary residual outflows
	ROW environment		11		Environmental inputs to production			Environmental inputs to consumption					Cross-boundary residual inflows	

4. A hybrid accounting matrix for the SEEAland data set

6.116 Table 6.8 constitutes an example of a full accounting matrix for the SEEAland data set. It builds on the SEEAland tables in chapters III, IV and V and is also consistent with similarly designated tables in other chapters. It was in such a format that the concept of a NAMEA was first popularized by Statistics Netherlands.

6.117 The first row and column of Table 6.8 represent a ***goods and services account***; the second row and column, a production account. Together, these two rows and columns cover exactly the same range of monetary data as that covered in Table 4.2. Thre is exact agreement for the totals for products and industries in the two tables. The degrees of detail within products and industries are different, however. In Table 6.8, the distinction is between environmental services, cleaner and connected products, and other goods and services. This means that the entries in these rows and columns can also be matched with the data appearing in Tables 5.6 and 5.7. In such a case, one would expect the data in Table 6.8 to contain information on ancillary activities measured in the same way as secondary activities, as described in chapter V.

6.118 One strength of the matrix presentation is that any sort of disaggregation can be used for products and industries. Usually, these will be in accordance with the conventional classifications, CPC and ISIC, respectively, although - as can be seen from this specific example – attention may be concentrated on only part of the classification with the reminder aggregated.

6.119 Since Table 6.8 is a hybrid account, the generation of residuals from production as well as the inputs into production of natural resources, ecosystem inputs and residuals are also shown. These figures exactly match those given in Table 4.3.

6.120 One difference introduced in the production account of Table 6.8 as compared with that of Table 4.2 is the disaggregation of value added into that part representing consumption of fixed capital and the remaining (net) value added. The entry for consumption of fixed capital occurs in the column for production and a row that will be used to record entries in the SNA capital account. This item should contain entries for use of all produced assets including the environmental consequences of them as discussed in section D.

6.121 The row and column labelled 2b represent the generation of income account and together with the row and column for tax receipts and payments (respectively) convert the balancing item from the production account which is value added at basic prices to a total at market prices as described in connection with Table 6.6. The figures for taxes in Table 6.8 are consistent with those shown in Table 6.2 and in Table 5.10.

6.122 The distribution of primary income account, comprising row and column 3, presents the impact of property income on the distribution of primary income. Part of this property income is the rent payable on environmental assets which is discussed in chapter VII.

6.123 Row and column 4 represent the secondary distribution of income account and, in particular, demonstrate how transfers affect the allocation of income among sectors. Taxes on income are explicitly identified so they can be aggregated with taxes on products and on production in the special row and column for taxes. If information is available on the current grants, or transfers, made between sectors to finance environmental protection, these can be shown by further disaggregating other transfers in this account. These flows are implicit in Tables 5.8 and 5.9 and would have been explicitly identified if a table such as Table 5.14 had been compiled. Other transfers are simply shown in this table on the diagonal element where row and column 6 intersect. In practice, this element would be disaggregated to show the flows between different sectors.

6.124 Rows and columns 5 relate to household consumption. The presentation is consistent with the discussion given above, thereby allowing for two different disaggregations of consumption to be shown. The entry in row 1 shows a disaggregation by product. By virtue of having a separate set of rows and columns for functions, the alternative classification by purpose (or function) can be given in row 5a. For reasons of space and because the product disaggregation chosen in row 1 is so close to a functional disaggregation separating environmental functions from others, only a single figure appears in the table. In addition to monetary flows, the volume of residuals generated by consumption activities can be shown in the columns at the far right of the table.

6.125 The use of income account in row and column 5b shows how disposable income is either spent on final consumption, either by households or by government, or saved.

6.126 The capital account is shown in row and column 6. In monetary terms, this account shows how saving is used to acquire new capital or lent to other sectors. Because borrowing and lending must offset one another, it is this account that is the basis for the requirement that savings and investment must be equal. It is also the account that shows whether the economy is operating in such a way as to maintain total non-financial capital.

6.127 The balancing item linking the use of income account and the capital account – saving - is measured net, but capital formation is typically measured gross because this is the measure of new capital put in place. It is thus necessary to add back the value of consumption of fixed capital before balancing this account. The capital account also includes the acquisition and disposal of property rights. Sale and purchase of land is one example of the exercise of property rights; the sorts of permits discussed in section C constitute another.

6.128 Saving can be redistributed by means of capital transfers and these also are shown in this account. Again, it is possible to specifically identify those that relate to environmental protection. Any other capital transfers would appear in the box where the sale and purchase of property rights are shown. They can be disaggregated by sector in a manner similar to that shown for current transfers.

6.129 The other feature of this table is the addition of physical information. The data in columns 11a and 11b show the flows of residuals. Here, for reasons of space, the only detail given is the distinction between the national environment destination and that of the rest of the world. For each of these columns, a breakdown by type of residual is possible, as in Table 3.12 and Table 4.3. Similarly, the rows for residuals, natural resources and ecosystem inputs at the bottom of the table can also be disaggregated.

6.130 Column 8 relates to the rest of the world economy. In the upper part of the column, exports of goods and services are shown flowing from the national economy to that of the rest of the world. In the lower part of the column, flows of natural resources and ecosystem inputs from the national environment to the rest of the world economy are shown. Natural resources that are first extracted by residents and then exported, for example, fish caught by national trawlers, will that in the upper section of the column. Only natural resources directly extracted by non-residents appear in the lower entries, for example, fish caught in national waters by non-resident trawlers. Natural resources first extracted by resident are recorded in this table in monetary terms (though physical data are usually also available) and natural resources directly extracted by non-residents in physical terms only (though the usefulness of assigning a monetary value to these also will be discussed in later chapters).

6.131 The entries in the upper part of the columns for residuals, corresponding to the rows for national and rest of the world economies, show the extent of residual generation by economic activity and whether this flows to the national environment or to that of the rest of the world. The entry in row 8 shows the extent of residuals generated by non-residents operating within the national territory. This can be compared with the extent of residuals generated in the rest of the world by residents in the course of production and consumption (shown, respectively, in rows 2 and 5a, column 11b).

Table 6.8 A hybrid accounting matrix (NAMEA) for SEEAland

		Goods and services (CPC)				Production (ISIC)	Generation of income account	Distribution of primary income account	Secondary distribution of income account	Household consumption
Economic sphere		1a	1b	1c	Total 1	2a	2b	3	4	5a
Goods and services (CPC)		*Trade and transport margins*				*Intermediate consumption*				*Household consumption*
Environmental protection services	1a					*9*				*3*
Cleaner and connected products	1b					*1*				*1*
Other goods and services	1c		*0*	*0*		*655*				*344*
Total products			*0*	*0*		*664*				*347*
Production (ISIC)	2a	*Output at basic prices* *14*	*1*	*1 272*	*1 286*					
Generation of income account	2b					***Net value added at basic prices*** *518*				
Distribution of primary income account	3						***Net domestic product at market prices*** *588*	*Property income* *100*		
Secondary distribution of income account	4							***Balance of primary income*** *588*	*Other transfers* *641*	
Household consumption	5a									
Use of income account	5b								***Disposable income*** *588*	
Capital account	6					*Consumption of fixed capital* *104*				
Financial account	7									
Taxes		*Taxes less subsidies on products*					*Taxes less subsidies on production*		*Taxes on income*	
Environmental taxes	Tax a			*3*	*3*		*2*		*2*	
Other taxes	Tax b	*0*	*0*	*67*	*67*		*2*		*66*	
Rest of the world	8	*Imports of products*	*0*	*363*	*363*					
Total for the economy		*14*	*1*	*1 704*	*1 719*	*1 286*	*592*	*688*	*1 297*	*347*
From the national environment						*Inputs to production*				*Inputs to consumption*
Natural resources	9a					256				1
Ecosystem inputs	9b					118				23
From the ROW environment										
Natural resources	10a					5				1
Ecosystem inputs	10b					3				1
Residuals						*Residuals reabsorbed by production*				
Generated by national economy	11a					7				
Cross-boundary flows from ROW	11b									

Monetary flows (in italics) in billions of currency units; physical flows in million of tons

Use of income account	Capital account	Financial account	Taxes	Rest of the world	Total for the economy	National environment	Rest of the world environment	Net flows to (+) and from (-) the environment		
5b	6	7	Tax	8		11a	11b			**Economic sphere**
Government consumption	*Gross capital formation*			*Exports of products*						Goods and services (CPC)
2	*0*				*14*				1a	Environmental protection services
					1				1b	Cleaner and connected products
157	*146*			*403*	*1 704*				1c	Other goods and services
159	*146*			*403*	*1 719*					Total products
					1 286	*Residuals from production* 275	5		2a	Production (ISIC)
			Taxes less subsidies on products and on production *74*		*592*				2b	Generation of income account
					688				3	Distribution of primary income account
			Taxes on income *68*		*1 297*				4	Secondary distribution of income account
Household consumption by purpose (COICOP) *347*					*347*	*Residuals from consumption* 47	1		5a	Household consumption
					588				5b	Use of income account
Saving *82*	*Purchase and sale of property rights* *3*				*189*	*Residuals from capital formation* 73			6	Capital account
	Net lending *40*				*40*				7	Financial account
										Taxes
					7				Tax a	Environmental taxes
					135				Tax b	Other taxes
		Current balance/net lending to the rest of the world *40*			*403*	*Residuals generated by non-residents* 6			8	Rest of the world
588	*189*	*40*	*142*	*403*	*9 012*	401	5	37		Total for the economy
				Inputs to ROW economy 1	258			-258		
				2	143			-143		
					6			-6		
					4			-4		
	Waste going to landfill sites 26				33		*Cross-boundary residual outflows* 4	373		
						Cross-boundary residual inflows 8		1		

6.132 The bottom right hand segment of the table shows the flows between the national and rest of the world environments only, that is, just the cross-boundary flows of residuals carried by environmental media in both directions.

6.133 The row for residuals near the bottom of the table shows the amount of residuals reabsorbed by production and also the amount destined for landfills, in the capital column. This recording of the disposal of residuals in landfill is the working assumption in the SEEA but the alternative of immediate disposal to the environment is discussed in chapter III. Cross-boundary residual flows to the environment of the rest of the world are also shown in this row.

6.134 The right-most column of the table shows the balancing items or net flows to the environment (if positive) and from the environment (if negative). Such balances are not shown separately for the rows in the economic sphere because they consist of the aggregation of the physical measures for products that are not shown in this table together with the physical measures for natural resources, ecosystem inputs and residuals that are shown. The total for the whole column, including those items not shown explicitly here, is still zero.

6.135 In this rather simplified set of monetary accounts, only imports and exports of products to and from the rest of the world are shown in monetary terms but the physical flows to and from the rest of the world feature as in Table 4.3.

6.136 This table omits a number of other flows that would appear in practice in a full set of national accounts. For example, Table 6.8 contains no information on transactions in financial assets and liabilities. Although Table 6.5 shows where entries for other transactions with the rest of the world would appear, no data values are shown here. Both current and capital transfers to and from the rest of the world could contain entries relevant to the financing of environmental protection expenditure.

5. Adding other physical data

6.137 The entire purpose of a hybrid account is to combine in the same presentational tables monetary data on economic flows and corresponding physical flows. Although such an account can be constructed to be entirely compatible with the SNA, the paragraphs above show how variations in the economic classifications are possible, as in the case of taxes, or how alternative classifications can be combined. Further, it is possible to add other data to the basic framework and one obvious candidate is information on labour. The national accounts show how much is paid by industries to households as compensation of employees but there is not even a headcount of employees included in the main flow accounts, though the SNA strongly recommends this be added as supplementary information. Within an accounting matrix, whether a purely monetary SAM or a hybrid one, a detailed labour accounting matrix can be added showing not just the number of employees but information relating to gender, age and skill level, to give only three examples. From this, it is possible to relate generation of residuals to the level and type of employment. For example, intensive agriculture or commercial mining results in large residual generation but few employees; peasant agriculture and artisanal mining may well lead to high levels of employment (though not necessarily income) and proportionately smaller levels of residual generation.

6.138 Analysis of the results of combining physical and monetary data must pay attention to the cross-correlations involved. A suggestion that low-paid women are more environmentally conscious than middle- income men may in fact simply reflect the fact that the former are mainly employed as shop assistants and in the health services, whereas the latter work in road transport and construction. Within these constraints, though, adding labour considerations to the accounting matrix is an important step towards considering economic, environmental and social issues simultaneously.

Chapter VII. Asset accounts and the valuation of natural resource stocks

A. Overview

1. Objectives

7.1. The basic aim of the SEEA accounting system is to show how natural resources and ecosystem inputs are drawn into the economy, and how products and residuals are generated. Chapters III - VI discuss aspects of product and residual generation and the means to combat the latter. The present chapter turns attention to the use of natural resources and ecosystem inputs in order to assess whether the stocks of these assets are being persistently depleted or degraded. In order to monitor the rate of depletion of a specific environmental asset, it is necessary to measure the stock of the asset at the start of an accounting period and to account for all the changes occurring during that period that determine the stock level at the end of the period. For natural resources, these changes are likely to be quantitative. For ecosystems, the qualitative changes may predominate. An accounting process that links opening and closing stock levels in an accounting period is called an asset account. This chapter describes how to compile asset accounts for different sorts of environmental assets in both physical and monetary terms.

7.2. Physical information on the degradation of ecosystem inputs is a necessary basis for all attempts to place a valuation on degradation. However, the debate on the necessity and means of establishing monetary values for degradation is much more controversial than the debate on valuing depletion. While the physical aspects of degradation are discussed in this chapter, the question of valuation techniques is postponed until chapter IX. In contrast, the present chapter addresses both the physical measures and monetary valuation of the depletion of natural resources.

7.3. The discussion of physical flows in chapter III and the development of the supply and use tables therein, and the discussion of the integration of these flows with the corresponding monetary flows in chapters IV and V, are the essential background for this chapter. The chapter is mainly theoretical and draws significantly on the economic accounting system of the SNA. It is not possible in the space available to give a complete review of all national accounting techniques and practices, but at the same time enough detail has to be provided for those national accountants who wish to understand the interface between the SNA and the SEEA. The result is that non-accountants may have to take on trust the statements that are sometimes made or to seek out a colleague who can help them find fuller underlying explanations. At the same time, national accountants reading this chapter will find some simplification, for the benefit of non-accountant readers, of national accounting issues peripheral to environmental accounting.

2. Defining environmental assets

7.4. One starts with the definition of an asset in the economic accounts and considers whether and how far this definition needs to be extended so as to cover the set of environmental assets of interest.

Integral to this is the development of a classification of environmental assets, which is the subject of section B.

7.5. Because the SEEA accounts are seen as an extension of those of the SNA, it is necessary to spend some time examining the relationship between the asset classification in the SNA and that proposed here for the SEEA. Different perspectives can be taken depending on whether the interest is in physical measures of assets or their monetary valuation. Both possibilities are examined since different sorts of analysis require one or the other, or sometimes both.

7.6. When looking at how changes in assets are incorporated in monetary accounts, it is necessary to make a clear distinction between those assets that are regarded as being "produced" (that is, those that come into existence as products resulting from economic production) and those that are "non-produced" (that is, those that occur as a result of purely natural processes). As with any dichotomy, there are problems at the boundary and these are also discussed in section B.

3. Form of an asset account

7.7. Section C introduces the idea of an asset account, initially in physical terms. The simplest form of an asset account shows how the closing stock of the asset can be calculated from the opening stock by adding and subtracting the changes that have taken place during the accounting period, generally a year. Asset accounts thus recall the accumulation accounts of the SNA. In the SNA, though, the accounts are usually drawn up for all assets of an institutional unit or sector; that is, the main interest is focused on the criterion of ownership rather than on the nature of the asset, though a disaggregation of assets by type is common at a second level. The SEEA asset accounts, in contrast, are concerned in the first instance with the nature of the asset and only secondarily (though not always) with the ownership of the asset by the various sectors of the economy.

7.8. The SNA asset account distinguishes four categories of changes in the assets recorded in the balance sheets. The first two of these are the sets of transactions recorded in the capital and financial accounts of the system. The third category, other changes in the volume of asset accounts, includes economic appearances and disappearances, and exceptional events such as natural disasters. Economic appearances relate not to physical appearances but rather to the case where a pre-existing entity is drawn into the economic sphere by acquiring an economic value. Economic disappearances cover the symmetric case where an asset loses its value or leaves the economy. The fourth and last category of changes is recorded in the revaluation accounts and includes valuation changes due to the effects of price changes.

7.9. In an asset account in the SEEA, some variations to the SNA categories are adopted. Economic appearance and disappearance are replaced by additions to and deductions from stock levels with some consequential changes for entries recorded as other changes in assets, though these still include price changes, the effects of catastrophic losses and change of ownership.

7.10. Section C discusses briefly how physical asset accounts may be compiled for each main class of environmental asset. More detailed information for minerals, forests, aquatic resources and land are given in chapter VIII.

4. Valuation

7.11. For many environmental assets, the type of information that is of interest in physical terms will reflect the physical characteristics of the asset and the uses to which it is put. This means that physical accounts for different sorts of assets are often of a rather specific character and do not lend themselves to aggregation or integration in a wider set of accounts. By contrast, the rationale for monetary accounts is that a consistent basis of valuation may be applied precisely so that aggregation across asset classes is possible and comparison can be made with non-environmental assets in terms of their respective contributions to the nation's wealth. Section D discusses the theoretical basis for valuation of assets in the SNA and the SEEA. Those who do not wish to consider the technical details may wish to read only the summary at the very end of the section which gives the key elements needed to determine values of different sorts of assets.

7.12. In order to convert an asset account in physical quantities into one in monetary terms, it is necessary to find a suitable means of determining the value of specific assets. Generally speaking, the SEEA uses the same principles of valuation as are used in the SNA but there are two restrictions connected with valuing assets based on the benefits yielded that must be addressed first.

7.13. Although the SNA is elaborated in purely conceptual terms, even in the manual itself and more particularly when accounts are actually compiled, it is recognized that some pragmatic compromises must be allowed in practice. The classification of assets is one case in point. Often a valuation is available only for a combination of assets, for example, a building and the land on which it is situated, regarded as a single "package". This inhibits valuing all the assets in the SEEA classification in the same detail and with the same distinctness as is achieved in physical terms. The areas where this is a particular problem are discussed in the first part of section D.

7.14. The second issue concerns the identification of the benefits and uses of assets such as those discussed in section B. In the market, the only question of interest is how much someone will pay for this asset. The issues of the benefits or uses of the asset are purely internal to the unit purchasing the asset and are not separately identified in the system. Two houses may have identical physical characteristics; but if one has a spectacular view and the other faces a brick wall, then the former will, in all probability, command a higher price. In effect, the direct use benefits of the two houses are the same but the former has a much higher indirect use than the latter. Many financial assets contain, explicitly or implicitly, option and bequest benefits. Increasingly, techniques are being introduced into national accounting to separate out some of these different characteristics, especially in the context of trying to distinguish quality change from price change.

7.15. The preferred method of valuing assets is by market price but this is very often not available for environmental assets. If environmental assets were valued in the marketplace as a matter of course, they would be absorbed within the SNA. The SEEA would be then a different sort of satellite account: one that worked within the SNA boundaries rather than one that extended them. In practice, land is the only non-produced asset that is widely valued and land has indeed been included in the SNA since its inception.

7.16. In the absence of market prices, other means of valuation have to be developed, drawing on what market transactions are available and, where these are missing, on estimation methods based on the economic theory of price and value. This in turn leads to a discussion of the expected length of life of the asset, the resource rent that it provides and what sort of discount factor should be used to value future returns at the present time. These issues form the subject of the latter part of section D.

7.17. In general, the market price of an asset should include an implicit valuation of all the benefits it can bestow on the owner. Even here, there are complications. The valuation that a household places on the durables it owns may be higher than the market price because it includes sentimental value, which would be recognized by members of the family but not by others. Similarly, some of the benefits from environmental assets may accrue to persons other than the owner of the asset and thus not be included in the market price. This may especially affect option and bequest values whose benefits will accrue non-specifically to future generations.

7.18. This chapter concentrates on establishing valuations that are consistent with market prices as currently observed. Issues relating to the valuation of other aspects of environmental benefits and functions are discussed in chapter IX.

5. Asset accounts in monetary terms

7.19. Section E shows how the valuation principles in section D can be applied to the physical accounts presented in section C to derive monetary asset accounts. The issue of the difference between physical quantities and economic volumes, first raised in chapter IV, is relevant here also. Since the principles to be applied vary from one type of environmental assets to another, there are separate subsections on the main assets.

7.20. The other issue addressed in section E is the question who owns the asset and who benefits from its exploitation. This is important in the context of how economic instruments are brought to bear on the management of environmental assets.

6. Linking asset accounts and flow accounts

7.21. The portrayal of the hybrid accounts in Table 6.5 includes all the flows connected with transactions in the system but no information about the level of stocks of assets. Section F shows how the presentation in Table 6.5 can be extended by the addition of the asset accounts to show the explicit linkage between stocks and flows in the system.

7.22. There is a direct link between the entries in the asset account, including the question of ownership, and the entries that appear in the flow accounts. This is an area where quite different views are held about whether and how the flow accounts should be brought into strict conformity with the asset accounts. This discussion of measuring the effects of depletion within the flow accounts is postponed until chapter X when it can be combined with a discussion on measuring the effects of degradation based on the discussion of valuation in chapter IX.

B. Environmental assets in the SEEA

7.23. The starting point for the consideration of the extent of environmental assets to be included in the SEEA is the coverage of assets in the SNA.

1. Environmental assets in the 1993 SNA

7.24. In economic accounting the definition of an asset is associated with the conferring of economic benefits on the owner of the asset. Thus, the 1993 SNA, for example, defines assets as "entities over which ownership rights are enforced by institutional units, individually or collectively; and from which economic benefits may be derived by their owners by holding them, or using them, over a period of time"(para. 10.2).

7.25. These benefits relate either to primary income derived from the use of the asset or simply to the fact that the asset in question represents a store of wealth that can be exchanged for another asset (including cash).

7.26. One feature of the 1993 revision of the SNA is the extended treatment given to assets and the recommendation for more careful and complete compilation of balance sheets and the accounts linking the balance sheets at the start and the end of the accounting period. Because interest in linking environmental issues to the economic accounts was already evident at that time, particular attention was paid to specifying among the full set of economic assets those relevant to the environment. The SNA states that "… naturally occurring assets over which ownership rights have been established and are effectively enforced, qualify as economic assets and (are to) be recorded in balance sheets. (Such assets) do not necessarily have to be owned by individual units, and may be owned collectively by groups of units or by governments on behalf of entire communities … in order to comply with the general definition of an economic asset, natural assets must not only be owned but be capable of bringing economic benefits to their owners, given the technology, scientific knowledge, economic infrastructure, available resources and set of relative prices prevailing on the dates to which the balance sheet relates or expected in the near future" (paras. 10.10 and 10.11).

7.27. Environmental assets that do not meet the above criteria fall outside the asset boundary of the 1993 SNA. In particular, environmental assets over which ownership rights cannot be established are excluded. These include elements of the environment such as air, major water bodies and ecosystems that are so vast or uncontrollable that effective ownership rights cannot be enforced. Likewise, resources whose existence has not been clearly established by exploration and development (speculative oil deposits, for example) or that are currently inaccessible (remote forests, for example) are not considered assets in the 1993 SNA. The same is true for resources that have been established geologically or are readily accessible but that bring no current economic benefit because they cannot be profitably exploited under prevailing economic or technological conditions.

7.28. Despite these restrictions, a number of important environmental assets are included in the SNA as economic assets. A distinction is made between those assets that come into being as a result of economic production (produced assets) and those that, though occurring in nature, are drawn into the economy (non-produced assets). For biological resources, the words "cultivated" and "non-cultivated" are used as synonyms for "produced" and "non-produced", respectively. For cultivated resources, a further distinction is made between plants and animals that yield the same product repeatedly over a period of time, such as dairy cattle and rubber trees, and those that yield a product only once, such as beef cattle and timber. These distinctions are discussed in greater length in annex I together with the detailed SNA definitions of the component items.

7.29. Table 7.1 presents (in bold roman type) the environmental assets covered within the 1993 SNA in the context of the classification hierarchy used there. There are also some assets included in the SNA that, though not themselves environmental assets, are closely related to them and to their exploitation. These are also included in **Error! Reference source not found.** (in bold italic type).

2. Environmental assets and functions

7.30. In the SNA, an asset – even an environmental asset – is defined in terms of the "benefit" as limited to the provision of income or a stock of wealth that can be converted to monetary terms. For the SEEA, the concept of an environmental asset is linked to the provision of environmental "functions", as explained in chapter I.

7.31. This extension is predicated on the notion of an environmental function. The environment is defined as the naturally produced physical surroundings on which humanity is entirely dependent in all its activities. The various uses to which these surroundings are put for economic ends are called environmental functions. When the use of one function is currently at the expense of the same or another function, or is expected to be so in the future, there is competition of functions. Thus, the function of a water body as a sink for residuals and its function as a source of drinking water are in competition. The high seas provide a habitat for fish but overfishing of one species may destroy another that preys on the first. The sea is then no longer a habitat for the latter species.

Table 7.1. Environmental assets within the 1993 SNA

- AN.1 Produced assets
  - AN.11 Fixed assets
    - AN.111 Tangible fixed assets
      - **AN.1114 Cultivated assets**
        - **AN.11141 Livestock for breeding, dairy, draught etc.**
        - **AN.11142 Vineyards, orchards and other plantations**
    - AN.112 Intangible fixed assets
      - ***AN.1121 Mineral exploration***
  - AN.12 Inventories
    - AN.122 Work in progress
      - **AN.1221 Work in progress on cultivated assets**
- AN.2 Non-produced assets
  - AN.21 Tangible non-produced assets
    - **AN.211 Land**
      - **AN.2111 Land underlying buildings and structures**
      - **AN.2112 Land under cultivation**
      - **AN.2113 Recreational land and associated surface water**
      - **AN.2119 Other land and associated surface water**
    - **AN.212 Subsoil assets**
      - **AN.2121 Coal, oil and natural gas reserves**
      - **AN.2122 Metallic mineral reserves**
      - **AN.2123 Non-metallic mineral reserves**
    - **AN.213 Non-cultivated biological resources**
    - **AN.214 Water resources**
  - AN.22 Intangible non-produced assets
    - AN.222 Leases and other transferable contracts

7.32. The re-existence of competing environmental functions results in the translation into economic entities of the environmental elements that provide those functions. They are scarce in that more of one entails less of the other. A sacrifice of some of the competing functions has to be made and therefore opportunity costs are necessarily involved in making the trade-off of functions. Some but not all of these trade-offs may translate into monetary terms.

7.33. Three types of competition among environmental functions can be distinguished: spatial, quantitative and qualitative. Spatial competition occurs when the amount of space available is inadequate to satisfy existing or expected future wants. For example, space for transport or agriculture may be at the expense of space for ecosystems. Quantitative competition covers such natural resources as oil, copper or groundwater which may become quantitatively insufficient in the future. Qualitative competition covers the case where changes in the type of species or substances cause changes to other possible uses such as physiologic functioning and habitat for other species.

7.34. Tracing the forces leading to competition of functions shows that the current use of the environment for production and consumption inhibits current and future availability of environmental functions, including those needed for future production and consumption. It is the need to maintain these functions in future and to investigate how present economic activity threatens them that explains the need to integrate environmental and economic accounting in both physical and monetary terms.

3. Environmental functions, benefits and uses

7.35. The functions provided by the environment yield a benefit to the economy. In chapter I, the functions were characterized as falling into one of three categories: resource functions, sink functions or service functions. Whichever of the three types of function is considered, the economy benefits from the use made of the function. One way to extend the SNA asset boundary is thus to express the benefits yielded by environmental assets in terms of the uses made of them. The benefits recognized in the SEEA can be grouped into two broad categories, use benefits and non-use benefits.

7.36. ***Use benefits*** include both direct and indirect benefits. ***Direct use benefits*** include the use of environmental assets as sources of materials, energy or space for input into human activities. ***Indirect use benefits*** do not change the physical characteristics of the environment and are sometimes described as "non-consumptive". The amenity benefit of landscape is one example.

7.37. Use benefits also include option and bequest benefits. ***Option benefits*** are those derived from the continued existence of elements of the environment that may one day provide benefits for those currently living. ***Bequest benefits*** are also derived from the continued existence of elements of the environment because they may one day provide benefits for those yet to be born. One example of these types of benefits is that derived from maintaining a rainforest to protect future sources of genetic material for drugs or hybrid agricultural crops.

7.38. In addition to these use benefits, an environmental entity may simply have an ***existence benefit***. In other words, without any prospect of the entity's being of use to humans now or in the future, it may be desirable to maintain its existence.

7.39. The inclusion of option, bequest and existence benefits effectively broadens the scope of the SEEA asset boundary to include all land and natural resources. In addition, ecosystems are included in the SEEA asset boundary on the grounds that they provide a variety of services that bring indirect use benefits to humans. These services include, among many others, the cleansing of polluted air and water. The fact that some environmental assets appear more than once within the classification – once in their own right and again as an integral part of another asset, as is the case for soil and land and also ecosystems – is useful when considering the physical aspects of environmental assets. It does not give rise to problems of double-counting in monetary terms because, usually, it is only the "integrated" asset for which a monetary value can be established. To the extent that the soil, for example, could be valued separately from land, the value of land would decrease by a matching amount.

7.40. While the SEEA asset boundary is in principle very broad, for practical reasons the environmental accounts actually compiled in any one nation will be much narrower. Actually accounting for each and every environmental asset would require an enormous amount of information, much, if not most, of which will not exist in most countries. Even for those assets for which useful information exists, building asset accounts may not be straightforward. Some benefits, such as carbon sequestration, may be more easily quantified in physical terms, so the practical possibilities for compiling physical asset accounts are less restricted than those for monetary accounts.

4. The SEEA asset classification

7.41. The classification of environmental assets used in the SEEA is presented in summary form in Table 7.2. The complete version of the classification is presented in annex I. In this table, assets are grouped according to three broad asset categories; natural resources, land and surface water, and ecosystems. The assets included within each of these categories are described in more detail below.

Natural resources in the SEEA (EA.1)

7.42. Natural resource assets are defined as those elements of the environment that provide use benefits through the provision of raw materials and energy used in economic activity (or that may provide such benefits one day) and that are subject primarily to quantitative depletion through human use. They are subdivided into four categories: mineral and energy resources, soil resources, water resources and biological resources.

Mineral and energy resources (EA.11)

7.43. Mineral and energy resources include subsoil deposits of ***fossil fuels***, ***metallic minerals*** and ***non-metallic minerals***. In the SEEA, these include not only the proved reserves (which are equivalent to the category AN.212 ("subsoil assets") of the 1993 SNA) but also probable, possible and speculative resources. The latter categories are included on the grounds that these provide option and bequest benefits insofar as they may one day provide direct use benefits. (In practice, some countries use a more expansive definition of reserves even for the SNA because of the form in which the basic data are available.) Substantive discussion of these categories appears in section E of this chapter and in section B of chapter VIII on mineral and subsoil deposits.

Table 7.2. SEEA asset classification

EA.1 Natural resources
EA.11 Mineral and energy resources (cubic metres, tons, tons of oil equivalents, joules)
EA.12 Soil resources (cubic metres, tons)
EA.13 Water resources (cubic metres)
EA.14 Biological resources
EA.141 Timber resources (cubic metres)
EA.142 Crop and plant resources, other than timber (cubic metres, tons, number)
EA.143 Aquatic resources (tons, number)
EA.144 Animal resources, other than aquatic (number)
EA.2 Land and surface water (hectares)
EA.21 Land underlying buildings and structures
EA.22 Agricultural land and associated surface water
EA.23 Wooded land and associated surface water
EA.24 Major water bodies
EA.25 Other land
EA.3 Ecosystems
EA.31 Terrestrial ecosystems
EA.32 Aquatic ecosystems
EA.33 Atmospheric systems
Memorandum items: Intangible assets related to environmental issues (extended SNA codes)
AN.1121 Mineral exploration
AN.2221 Transferable licences and concessions for the exploitation of natural resources
AN.2222 Tradable permits allowing the emission of residuals
AN.2223 Other intangible non-produced environmental assets

Soil resources (EA.12)

7.44. Soil resources include soil found on agricultural land as well as that found elsewhere within the national territory. There is no corresponding asset category in the 1993 SNA since soil is included with the land that it covers.

7.45. In practice, it is agricultural soil that is of greatest importance in most countries from a natural resource perspective and it is likely that most countries would focus their soil accounts here. The ecological functions of soil are implicitly included. Topsoil that is extracted from one place and used to supplement soil elsewhere may be of sufficient importance in some countries to warrant compilation of an account. Sand and gravel resources are generally defined to be part of non-metallic mineral resources rather than soil resources. In some instances, the distinction between topsoil and sand and gravel is not clear-cut and it may be the case that topsoil resources end up included in the measurement of sand and gravel or vice versa.

7.46. It must be recognized that estimating the total stock of soil resources in physical terms may be very difficult, even for countries with sophisticated land statistics. Thus, the physical account for soil may show only the change in soil resources from one period to the next. Since soil forms very slowly, in practice the only change that would be shown in such an account would be the depletion of agricultural soil due to erosion or the extraction of topsoil. It should be noted that qualitative degradation of soil due to compaction, salinization, loss of organic matter and other impacts of economic activity is accounted for in principle elsewhere in the classification. The loss in monetary value due to degradation of agricultural soils or depletion in the form of erosion is implicitly included in the value of agricultural land. The loss of ecological functions due to soil degradation is implicitly included in the measures of terrestrial ecosystems.

Water resources (EA.13)

7.47. Water resources are defined as the water found in fresh and brackish ***surface water*** and ***groundwater*** bodies within the national territory. In the case of surface water, the volume in artificial reservoirs and watercourses is included in addition to that in natural water bodies. The water of the oceans and open seas is excluded on the grounds that the volumes involved are so enormous as to make any stock measure meaningless and that extraction for human use has no measurable impact on them.

7.48. The 1993 SNA recognizes only groundwater resources as a distinct asset and then only "aquifers and other groundwater resources, to the extent that scarcity leads to the enforcement of ownership and/or use rights, market valuation and some measure of economic control". (This is the definition of AN.214 given in the annex to chapter XIII of the SNA.) The SEEA extends this to include all groundwater resources on the basis that those that do not provide current use benefits may one day do so and therefore provide option and bequest benefits.

7.49. Surface water is not recognized as an explicit asset in the 1993 SNA. It is mentioned in the SNA asset classification only in association with land areas that are within the asset boundary. Surface water is, however, not fundamentally different from many other natural resources in that it can be extracted from the environment and brought into the economic system for use in a variety of ways. The SEEA therefore recognizes surface-water resources as environmental assets because they provide use benefits.

7.50. In some countries, the quantity of water found in surface-water and groundwater bodies is also enormous, hence compiling a stock estimate for all such water is of questionable value, to say nothing of its being a daunting task. In such countries, a pragmatic approach to water resource accounting could be to focus on only those water bodies that are in close enough proximity to human populations to play an important role in provision of water for human and industrial use.

7.51. This leads to the possible consideration that it is only water available for use that should be counted. One of the problems associated with water is the following: insofar as it may be located in the wrong place or available at the wrong time, it will not be beneficial. Flood water, for example, may be plentiful but not necessarily useful.

7.52. The ecological functions of water are included in the SEEA under aquatic ecosystem assets (EA.32).

Biological resources (EA.14)

7.53. Biological resources include ***timber resources***, ***crop and plant resources***, ***aquatic resources***, and ***animal resources other than aquatic*** that bring use benefits today or that may do so in the future. Each category of biological resource in the SEEA asset classification is subdivided into cultivated and non-cultivated subcategories.

7.54. The cultivated biological resources recognized in the SEEA are very similar to what the 1993 SNA calls cultivated fixed assets (AN.1114) and work in progress on cultivated assets (AN.1221). The non-cultivated biological resources recognized in the SEEA include those recognized as economic assets in the category of the same name in the 1993 SNA (AN.213). In addition, the SEEA includes non-cultivated resources that provide no current use benefit but that may one day do so (that is, those with current option and bequest benefits). In practice, this means that conceptually all non-cultivated biological resources within the national territory fall within the SEEA asset boundary.

7.55. For both environmental and economic accounting, a key decision has to be made about when the growth in biological assets is to be regarded as production and when it is not to be so regarded. The basic criterion concerns how far the process is controlled by human intervention. Fish raised in a fish farm are regarded as produced; those caught on the high seas are regarded as non-produced. Cattle and sheep raised on farms for milk, wool and meat are produced; wild game is non-produced. This leads to the usage of the words "cultivated" and "non-cultivated" instead of "produced" and "non-produced" for biological resources.

7.56. Inevitably, though, there are problems related to the boundary between what is cultivated and what is not. A typical example concerns forests. A virgin forest in a remote area is non-produced and one that is planted, tended, felled and replanted on a regular cycle with continual labour inputs is produced; but which category applies to a forest where, once the initial planting is done, nature is left to take its course (with little if any human intervention) until the forest is mature enough for felling?

7.57. The SNA (chap. XIII, annex) defines cultivated fixed assets as "livestock for breeding, dairy, draught etc. and vineyards, orchards and other plantations of trees yielding repeat products that are under the direct control, responsibility and management of institutional units" and work in progress on cultivated assets as "livestock raised for products yielded only on slaughter, such as fowl and fish raised commercially, trees and other vegetation yielding once-only products on destruction and immature cultivated assets yielding repeat products". Extensive discussion has shown that these definitions are not sufficiently precise. It needs to be made clear that control over the harvesting is not sufficient to establish the fact that a biological asset is produced. If it were sufficient, the existence of any legislation controlling the use of virgin forests would permit a designation of "produced".

7.58. In defining non-cultivated biological resources, the SNA specifies "animals and plants that yield both once-only and repeat products over which ownership rights are enforced but for which natural growth and/or regeneration is not under the direct control, responsibility and management of institutional units". It is proposed, therefore, that the definition of cultivated assets, even in a purely SNA context, should be expanded by replacing the words "that are" with those in bold italics so as to read "livestock for breeding, dairy, draught etc. and vineyards, orchards and other trees yielding repeat products ***whose natural growth and/or regeneration is*** under the direct control, responsibility and management of institutional units".

7.59. Further, it should be understood that the processes involved must constitute production in the SNA sense and not consist of just legislative control. Examples of production are (a) control of regeneration, for example, seeding, planting of saplings, controlling the fertility of livestock; and (b) regular and frequent supervision of animals/plants to remove weeds or parasites, attend to illnesses, or restrict the area over which the animals may roam to a supervised or otherwise designated area. It should normally be the case that the process of production has been classified to the corresponding industrial activity (agriculture, forestry or fishing). That it only be part of government administration should not be sufficient. Further, the level of this production activity has to be significant relative to the value of the resource and directly connected with the forest, animal or fish stock in question.

Land and surface water in the SEEA (EA.2)

7.60. Whereas the 1993 SNA includes only land areas over which ownership has been established and that can be put to economic use (para. 12.18), the SEEA explicitly includes all land on the grounds that it might one day provide use benefits even if it does not do so today.

7.61. Land and surface-water assets are defined as the areas within the national territory that provide direct or indirect use benefits (or that may provide such benefits one day) through the provision of space for economic and non-economic (for example, recreational) human activities. Land and surface-water assets are subdivided into five categories: land underlying buildings and structures; agricultural land and associated surface water; wooded land and associated surface water; major water bodies; and other land.

7.62. Within the SNA, recreational land is one of the exhaustive categories of land. The principle basis for the SNA categorization is that of economic value. Thus land that is used for both agriculture and recreation is treated either as agricultural or recreational land, depending on whether its value as agricultural land exceeds that of its value as recreational land or vice versa. In the SEEA, the categories are determined by use. Since recreational land typically has a dual use, it can legitimately be allocated to two headings. In order to have a categorization where the sum comprises the total available land area, recreational land can be shown as an "of which" item under the relevant headings. The aggregate of all recreational land across all categories can be shown as a proportion of the total but could also be included in the specific sub-components.

Land underlying buildings and structures (EA.21)

7.63. Land underlying buildings and structures corresponds to the 1993 SNA asset category of the same name (AN.2111) if one expects the qualification on recreational land just noted. The SEEA asset classification goes beyond that of the 1993 SNA, however, in identifying subcategories of land underlying buildings and structures ***within urban areas*** and ***outside urban areas***. The conception of an urban area will vary from country to country, but a working definition is "any area where at the time of the most recent census there was a population of 1,000 or more persons and a population density of 400 or more persons per square kilometre".

Agricultural land and associated surface water (EA.22)

7.64. Agricultural land and associated surface water are equivalent to the 1993 SNA category "Land under cultivation" (AN.2112) if one expects the qualification on recreational land noted above and the exclusion of plantations included in EA.23 below. The SEEA goes beyond the 1993 SNA in identifying specific subcategories of agricultural land: cultivated land, pasture land and other agricultural land.

7.65. ***Cultivated land*** is defined in the SEEA as land used for the growing of crops on a cyclic basis (for example, grain or vegetables) or a permanent basis (vineyards, orchards etc.). Land that is normally cultivated but that has been allowed to go temporarily fallow is included in the cultivated land category. ***Pasture land*** is land that is used for the grazing of livestock and includes both land that has been improved through drainage or clearing and land that is in an essentially natural state. ***Other agricultural***

land includes small areas of wooded land, surface water, feed lots and miscellaneous land found within agricultural holdings.

7.66. Soil associated with agricultural land is classified as a natural resource in the SEEA, as discussed above.

Wooded land and associated surface water (EA.23)

7.67. Wooded land and associated surface water in the SEEA includes forested land and other wooded land. Forested land is defined as land under cultivated or non-cultivated stands of trees of a size of more than 0.5 hectares with crown cover of more than 10 per cent and on which trees are able to grow to a height of five metres or more at maturity. Other wooded land is defined as land either with a crown cover of 5-10 per cent of trees able to reach a minimum height of five metres or with a crown cover of more than 10 per cent of trees not able to reach a height of five metres.

7.68. Forested land is, in principle, classified by the SNA with other land under cultivation (AN.2112). Some wooded land may be either included in the residual SNA heading of other land and associated surface water (AN.2119) or omitted from the SNA altogether if the land is so remote or so protected that no economic value is envisioned in the foreseeable future.

7.69. The value of the ecological functions provided by wooded land, to the extent that this can be calculated, is captured in the value of forest ecosystems (EA.313).

Major water bodies (EA.24)

7.70. Major water bodies are defined in the SEEA as bodies of water large enough to be separately identified from the surrounding land. The size at which a water body can be considered "major" is, of course, dependent upon the resolution of the underlying land statistics. With the advent of geographical information systems technology and remotely sensed land statistics, it is possible to collect and manipulate large volumes of detailed land statistics. In countries in which these technologies are available, the term "major water body" is likely to include smaller water bodies than those encompassed by the term in countries with more basic land statistics.

7.71. The 1993 SNA asset classification has no specific category for surface-water bodies though, as in the SEEA classification, all the land categories include associated water. To the extent that major water bodies meet the criteria for definition as economic assets, they are implicitly included in the 1993 SNA as part of other land and associated surface water (AN.2119).

Other land (EA.25)

7.72. This residual category includes all land not previously allocated to one of the other headings in the present section. It includes those parts of the SNA categories of recreational land (AN.2113) and other land (AN.2119) not included in any other SEEA category. Areas of recreational land not included in previous headings, such as sports facilities and open recreational spaces, appear under this heading but, again, they can be shown as an "of which" component. For geographically compact and densely populated countries, it is probable that all the land of the territory will be included in one of the SNA categories. For countries with large, sparsely populated areas, especially if these are climatically harsh, there may be areas with no foreseeable economic value. These would be excluded from SNA assets but included within the SEEA asset boundary, where they would fall into the present category.

Ecosystems in the SEEA (EA.3)

7.73. The third broad category of environmental assets recognized in the SEEA comprises ecosystem assets. Ecosystems can be defined simply as groups of organisms and the physical environment they inhabit (Ricklefs, 1990). They are recognized as assets in the SEEA for their provision of indirect use benefits to humans in the form of a variety of services, including the cleansing of fouled air, water and soil, protection against solar radiation, regulation of geochemical flows and others. Measuring the services provided by ecosystems is difficult and measurement of the basic stock even more so. Nevertheless, it is important to recognize that, conceptually, such a stock exists and that it constitutes this type of environmental assets in the SEEA.

7.74. With the exception of natural resources that provide direct use benefits, the individual organisms and physical features that make up ecosystems are not classified as unique assets in the SEEA. This reflects the fact that it is not generally the components of ecosystems that benefit humans, but the systems as a whole. However, because natural resources are recognized as specific assets, some elements of the environment appear twice in the SEEA asset classification, once as natural assets and once as components of ecosystems. Thus, forests that are used as a source of timber are classified as natural resource assets. Since they provide other benefits as well (carbon absorption, for example), these same forests are also classified as ecosystem assets, reflecting the fact that they provide more than one kind of benefit. As natural resources, they provide direct use benefits, while as components of ecosystems they provide indirect use benefits. It is necessary to recognize both roles of forests and other biological resources if a complete picture of the benefits provided to humans by the environment is to be captured in the SEEA. It should be noted, however, that the inclusion of ecosystems, like soil, as a separate category implies that there is an element of double counting in the SEEA classification, deliberately introduced to enable different environmental aspects to be examined.

7.75. Three types of ecosystem assets are recognized in the SEEA; ***terrestrial ecosystems***, ***aquatic ecosystems*** and ***atmospheric systems***.[23] Each of these is further subdivided according to the major types of subsystems found on the planet. Still further subdivision is possible to meet the needs of individual countries. For example, forest systems could be further subdivided into coniferous, deciduous and mixed wood subcategories, each of which could be subdivided again according to the naturalness of the forest.

7.76. A few services are common to all three broad systems inasmuch as they all play a role in regulating global material and energy flows, absorbing human wastes and providing environmental amenities. Other services may be offered by some systems and not by others. If they so desire, countries may further subdivide the ecosystems headings in their asset classifications to identify each of the services provided by a specific environmental system and may attempt to provide separate statistics for each service.

C. Accounting entries for an asset account

7.77. The structure of an asset account is shown in Table 7.3. As explained at the outset of this chapter, the objective is to enumerate the causes of change in the level of stocks throughout the year so that the opening and closing stock levels can be reconciled.

7.78. Most of the changes are the effect of either economic activities or natural processes. One of the differences between the SNA and the SEEA concerns the way in which these different types of changes

[23] The term "atmospheric systems" is used instead of "atmospheric ecosystems" because the atmosphere is abiotic, whereas ecosystems by definition include biotic and abiotic elements.

are recorded, hence it is important to separate them. In those occasional cases where an exact separation will not be possible, there should be a judgement regarding the dominant cause in order that the corresponding attribution may be made.

Table 7.3. A generic asset account for a physical asset

Opening stock levels
Increases in stocks
Due to economic activity
Due to regular natural processes
Decreases in stocks
Due to economic activity
Due to regular natural processes
Due to natural disasters (net decrease)
Changes due to economic reclassification
Closing stock levels
Changes in environmental quality
Due to natural processes
Due to economic activity

1. Units of account

7.79. Natural resources, land and ecosystems may be measured in physical quantities using units such as hectares, tons and/or cubic metres. Physical accounts may also be compiled by quality classes. For example, forest, measured in hectares or cubic metres, may be subdivided on the basis of cover species, ownership, management regimes, naturalness, degrees of defoliation and so on. Annex I, which shows the detailed asset classification proposed for the SEEA, includes suggestions on alternative units of measurement of different assets. The subject is also discussed in chapter III where accounts in physical units are elaborated and in chapter VIII where resource accounts for different resources are discussed.

7.80. Obviously, for an account such as that portrayed in Table 7.3 to be workable, each line must be expressed in the same units. For assets such as water and atmospheric systems, there is no meaningful way of measuring total stock levels. Further, it will often be impossible to express a quality change in terms of the same units as those of other entries. In these cases, the additive asset account is augmented or even replaced by a series of environmental indicators that express the change in terms of some other units. One example involves using an air quality index to measure changes in the quality of air; another, the use of changes in nutrients to represent changes in soil. The health status of forests and the quality of water bodies may also be studied by means of supplementary physical accounts.

2. Asset accounts in the SNA

7.81. The 1993 SNA presents an asset account in the appendix to the annex to chapter II (table 2.7) but it is little known and not in common use. It is, however, a very useful device to explain how the various accumulation accounts can be combined to account for the changes between the opening and closing balance sheets. The principles behind this relationship are explained in paragraph 10.15 of the 1993 SNA and shown schematically in its table 13.2. The accumulation accounts consist of the balance sheets and three flow accounts. The ***capital account*** covers transactions in non-financial assets and the ***financial account*** covers transactions in financial assets and liabilities. Another account, the ***other***

changes in assets account, itemizes the causes of changes in value of assets appearing in the balance sheet that are not regarded by the SNA as being due to transactions. It is nonetheless essential in reconciling the opening and closing balance sheets. In terms of the SNA accounts, the following identity must hold:

stock levels as in the opening balance sheet

plus entries on non-financial assets in the capital account

plus entries on financial assets from the financial account

plus entries from the other changes in assets account

equals stock levels as in the closing balance sheet

7.82. The structure of an SNA asset account for a non-financial asset is presented in Table 7.4.

Table 7.4. An asset account for a non-financial asset

Opening stocks
Entries in the capital account
Gross fixed capital formation
Consumption of fixed capital
Changes in inventories
Acquisitions less disposals of valuables
Acquisitions less disposals of non-produced non-financial assets
Entries in the other changes in assets account
Economic appearance of non-produced and produced assets
Natural growth of non-cultivated biological resources
Economic disappearance of non-produced assets
Catastrophic losses
Uncompensated seizures
Other volume changes in non-financial assets n.e.c.
Nominal holding gains/losses
Changes in classifications and structure
Closing stocks

7.83. Many uses of the SNA focus on the role of produced and financial assets. For these, most of the changes between the stock levels in the opening and closing balance sheets will be shown in the capital account for produced assets and in the financial account for financial assets and liabilities. For these assets, the other changes in assets account is simply the place in which to record exceptional events and revaluations due to changes in relative and absolute prices.

Economic appearance and disappearance

7.84. When the 1993 SNA extended the asset boundary to include more non-produced assets including environmental assets, it was recognized that provision had to be made for recording their entry into the balance sheet and, sometimes, their exit from it. The other changes in assets account accommodates such entries also. The SNA uses the terms "economic appearance" and "economic disappearance" to describe how it comes about that non-produced items are treated as being within the SNA asset boundary.

7.85. There are basically three ways in which items may cross into the asset boundary. A new non-produced asset may be created by constructing a legal instrument, a fishing quota or an emissions permit, for example. New environmental assets may be recorded as having come into existence other than through production processes, by means, for example, of the discovery of new mineral deposits or the natural growth of biological resources, both involving a quantitative addition to the stock. The third way in which an asset may be created is through a change in conditions whereby something that had no economic value previously acquires one. This may be due to changes in relative prices, or to the possibilities opened up by new technologies, changes in legislation or consumer taste. There are corresponding ways in which assets may cross out of the asset boundary.

7.86. Within the SNA, the existence of an associated physical quantity is irrelevant to whether something is treated as an asset or not. These examples of how items come to be treated as an asset show that there may or may not be an associated physical quantity and that, even when there is, there may or may not be a change in this quantity. It is only the acquisition (or loss) of economic value that determines when economic appearance (or disappearance) is recorded.

Other non-transactional changes in assets

7.87. A significant cause of change may be the effect of a natural disaster on any assets including natural resource stocks and ecosystems. By convention, these are shown as a special type of decrease of assets but it should be remembered that for some assets a disaster may lead to a physical increase, for example, a flood may lead to an increase in the volume of water present in a given area.

7.88. The terms "economic appearance" and "economic disappearance" are used only in the case of non-produced assets (although these include intangible non-produced assets as well as the tangible non-produced assets that correspond to the non-produced environmental assets of interest in the SEEA). By definition, produced assets cannot come into existence through "economic appearance" with the only exception of valuables and historic monuments: they appear as a result of production and are recorded as such in the capital account. They are normally eliminated from the balance sheet by means of the allowances for consumption of fixed capital which is also recorded in the capital account. Sometimes, however, there may be events that necessitate a sudden complete elimination from the accounts of the remaining value of a produced asset, for example, through unforeseen obsolescence. These are recorded as other changes in assets.

7.89. An important cause of change in the other changes in asset accounts relates to changes in prices due either to increases (or decreases) in the overall price level or to changes in relative prices. Revaluation changes always reflect the change in the value of an asset, that is, they always affect something classified as an asset both before and after the price change. If the value of a non-produced asset before the price change was zero, or becomes so after the price change, then this change is recorded under appearances and disappearances as noted above. Changes in value of non-produced assets that can be attributed to changes in the physical attributes of the asset are also so classified. If the asset is produced, the effect of a price change that reduces the value to zero is recorded under other changes in assets as described in the previous item.

7.90. The last cause of change is economic reclassification. For example, land previously used for agriculture may be built over and so may go from being classified as cultivated land to being classified as land under buildings. Or, a public enterprise may be privatized, and, although it retains ownership of its assets, they may move from the public to the private sector.

3. Asset accounts for environmental assets in the SEEA

7.91. The SNA shows how an asset account can be compiled for non-produced assets as well as for produced and financial assets. However, within the SEEA, the fact that the asset boundary has been extended has a significant consequence for the resulting asset account, quite apart from the obvious fact that, for environmental assets, the entries that the SNA places in the other changes in assets account are much more significant than those appearing in the capital account.

7.92. Within the SNA, an entity can be classified as an asset only if it is owned and may yield economic benefits to the owner. Although some of the SEEA assets have no economic value, they are nonetheless within the SEEA asset boundary insofar as they offer indirect use benefits, option and bequest benefits or simply existence benefits that cannot be translated into a present-day monetary value. This may be due to the fact that the exact future use is unforeseen and so cannot be valued in terms of today's system of economic prices even before discounting is considered, which explains why some entities with zero monetary value are treated as assets in the SEEA but not in the SNA.

7.93. A consequence of this wider asset boundary is that entities cross it much less frequently than is the case for SNA assets. Basically, once an environmental asset is within the SEEA asset boundary, it stays there until it ceases to exist, regardless of what happens to its monetary value. Non-produced assets such as emission permits which have no associated physical attributes are categorized by the SNA as intangible. The treatment of these assets is not at issue here so we put them to one side. For the remaining non-produced assets (tangible non-produced assets in the SNA, non-produced environmental assets in the SEEA), in place of economic appearance and disappearance we are interested in changes in the assets whether these are in quantity terms only or in quantity and monetary terms. To make this distinction with respect to the SNA clear, the previous categories of economic appearance and disappearance are replaced in the SEEA by those encompassing additions to and deductions from stock levels. It should be remembered that these relate only to non-produced environmental assets. Increases and decreases in produced biological assets will continue to be recorded as capital formation or changes in inventories, as appropriate, in the capital account.

7.94. The following sections indicate in more detail exactly which sorts of items are to be included under the different headings. This explanation is given in terms of the classification of "other accumulation entries" which appears in the SNA. These items are the entries that are not the result of economic transactions; they have to be included in the asset account along with the economic transactions to explain the accounting relationship between the opening and closing balance sheets. As it turns out, these are sufficiently comprehensive to cover all the changes to environmental assets that should be captured in an SEEA asset account. In fact, only two of the SNA items are not relevant. One of these relates to financial assets and liabilities; the other, to the special case of valuables and historic monuments.

Changes due to transactions

7.95. For produced assets, the main transactions concern the acquisition less the disposal of these assets, referred to as gross fixed capital formation and changes in inventories.

7.96. **Gross fixed capital formation** relates to the acquisition less disposal of fixed assets. Fixed assets are themselves defined as produced assets that are used repeatedly or continuously in production processes for more than one year. Gross fixed capital formation is further disaggregated into three sub-headings, all of which are relevant for environmental accounting. ***Tangible fixed assets*** cover animals such as dairy cattle, sheep reared for wool, fruit bearing trees, vineyards and so on. ***Intangible fixed assets*** cover mineral exploration. Land improvements are included under the last subheading, namely, ***additions to the value of non-produced non-financial assets***. This includes decontamination of polluted land, and restoration of quarries and landfill sites as well as measures designed to improve the quality of agricultural land.

7.97. **Inventories** are stocks of produced goods held by producers that are intended for sale, use in production or other use at a later date. The fact that, unlike fixed assets, inventories are used once only explains why animals and plants that provide a benefit only when they are slaughtered or harvested are included here. At the level of the national economy, changes in inventories record the balance of all acquisitions and disposals of inventories by producers during the accounting period. Inventories are separated into materials and supplies, work in progress, finished goods and goods for resale. For environmental accounting, the relevant category is a subdivision of work in progress related to ***work in progress on cultivated assets***.

7.98. For single-use cultivated biological assets, the growth until harvesting should be recorded as work in progress under the heading of change in inventories. The growth of animals and plants that will be used repeatedly or continuously in production when they reach maturity is recorded as gross fixed capital formation, unless they are being cultivated or reared for sale by specialist producers. In the latter case, the growth until maturity is treated as work in progress.

7.99. **Consumption of fixed capital** shows the decline in value of a fixed capital asset due to its use in production during the period between an opening and closing balance sheet. Consumption of fixed capital should appear in the production account, reducing gross value added to net value added. Net value added is thus a measure of income that assumes that the level of assets can be kept intact. To the extent that gross capital formation exceeds consumption of fixed capital, the level of fixed assets in the economy is increasing. If consumption of fixed capital exceeds gross fixed capital formation, then the economy is not maintaining the level of its fixed capital stock.

7.100. Consumption of fixed capital applies to all fixed assets, including those cultivated biological assets that are considered to be fixed assets and land improvement. It also applies to costs of mineral exploration that have been recorded as fixed capital.

7.101. **Acquisitions less disposals of non-produced non-financial assets** relate to the purchase and sale of land or of mineral and energy resources. In principle, they could also cover the sale of a virgin forest or similar environmental asset but such transactions are unlikely to occur often in practice. They also covers the acquisitions less disposals of intangible non-produced assets. Thus, sales and purchases of fishing quotas, emissions permits and similar licences are recorded here.

Changes not due to transactions

7.102. There are three categories of changes not due to transactions in the SEEA asset account, as in the SNA asset account, but here the headings are additions to stock levels, deductions from stock levels, and other changes in stock levels.

Additions to stock levels

7.103. This heading includes items from the SNA other changes in assets account, namely, economic appearance of non-produced assets (SNA item K.3), natural growth of non-cultivated biological resources (SNA item K.5) and part of changes in classifications and structure (part of SNA item K.12).

7.104. ***Discoveries*** include gross additions to the level of proven reserves. These are recorded in the SNA as economic appearance of non-produced assets, that is, as a transfer to the economy. Discoveries of subsoil assets that are not yet proven and natural growth of biological assets without an established monetary value do not appear in the SNA but should in principle be covered by the SEEA.

7.105. ***Reclassification due to quality change and reclassification due to change in function.*** As an example, one may consider the case in which agricultural land is used as built-up land. The SNA would record the change in economic use as change in classifications and structure and the increase in value as part of the economic appearance for built-up land. If an asset is reclassified from a produced asset to a non-produced asset, it will be included here also (though offset by a compensating change for produced assets).

7.106. The item ***natural growth of non-cultivated biological resources*** is self-explanatory.

Deductions from stock levels

7.107. This heading includes items from the SNA other changes in assets account, namely, from economic disappearance of non-produced assets (SNA item K.6). It also includes reclassification from non-produced to produced asset status (again part of item K.12 and again offset by a corresponding heading under produced assets). In principle, part of other volume changes in non-financial assets not elsewhere classified (n.e.c.) (SNA item K.9) relating to degradation of environmental assets should be included here also. As with all degradation of environmental assets, placing a value on this may be difficult in practice.

7.108. ***Extraction of natural resources*** is recorded in the SNA as part of economic disappearance of non-produced assets. It includes depletion of natural resources and reductions in the level of exploitable subsoil resources. Depletion in the SNA covers the reduction in the value of deposits of subsoil assets as a result of the physical removal and using up of the asset. It also covers the depletion of natural forests, fish stocks in the open seas and other non-cultivated biological resources as a result of harvesting. The valuation of depletion in the SEEA is discussed in section D below and in more detail in chapter X.

7.109. ***Environmental degradation of non-produced assets*** includes degradation of land and water resources and other natural assets due to economic activity. It also includes the decrease in value of such environment-related assets as emissions permits. Although degradation is reflected in the asset accounts discussed in this chapter, its valuation is particularly complex and a separate chapter (chap. IX) is devoted to its discussion.

7.110. The item ***Reclassification due to quality change and due to change in function*** is explained in paragraph 7.105 above.

7.111. The SEEA physical accounts do not treat as deductions from stock items that continue to exist but are no longer economically viable, though the monetary value will decrease correspondingly. While the SNA records subsoil resources as entering and exiting the asset boundary depending on economic viability, the physical SEEA accounts will maintain the recording of such deposits once discovered until they are extracted or otherwise physically disappear.

Other changes in stock levels

7.112. This item covers the remaining (parts of) items from the SNA other changes in assets account that cannot be attributed to the interaction between the economy and the environment as well as one item that is related simply to the change in ownership from one economic unit to another.

7.113. ***Catastrophic losses*** (SNA item K.7) cover the effects of earthquakes, volcanic eruptions, tidal waves, hurricanes, droughts, floods and other natural disasters as well as wars and toxic spills which can be more immediately traced to human intervention. The possibility exists of treating some or all of the elements of this item differently in an alternative version of the SEEA account.

7.114. ***Uncompensated seizures*** (SNA item K.8) rarely occur but can in theory affect environmental as well as other assets.

7.115. ***Degradation of produced assets*** is included in the SNA as part of other volume changes in non-financial assets not elsewhere classified (remaining part of SNA item K.9).

7.116. ***Nominal holding gains and losses*** (SNA item K.11) affect only monetary valuations of the accounts and represent the change in value of an asset due simply to the overall change in prices (nominal gains or losses) or changes due to movements in relative prices (real holding gains and losses). The content of this revaluation item was discussed in more detail above under the SNA account.

7.117. ***Changes in classifications and structure*** (the remaining part of SNA item K.12) involve no change in value or volume of an asset but relate mainly to the change of ownership from one type of unit to another.

Form of the account

7.118. Table 7.5 shows a scheme that could in principle be completed for any type of SEEA asset. The shaded cells in the table indicate where, in principle, entries are possible. While such an account could be drawn up in monetary terms for some of the assets, for some others only physical accounts are likely to be possible at the moment. For some assets, water, for example, there may be no comprehensive stock measure available and yet it is both practicable and useful to draw up a table of changes in the stocks in a format like this.

7.119. At the present time, there is unlikely to be sufficient information available to draw up either stocks of ecosystems assets or a comprehensive measurement of changes during a year in exactly the same manner as for other environmental assets. There is no reason in principle, though, why an asset account for an ecosystem could not be constructed. It may be more useful, however, to concentrate on measuring changes in quality rather than just changes in quantity as exemplified in Table 7.5. Most often such changes will relate to degradation. Examples include the acidification or eutrophication of land and water and defoliation of timber. However, there will also be instances of amelioration especially as a result of activities designed to restore environmental functions.

Table 7.5. A SEEA asset account schema

	Produced assets	Natural resource stocks				Land
		Mineral and energy	Water	Biological resources		
				Produced	Non-produced	
Opening stocks						
Changes due to transactions						
Gross fixed capital formation						
of which land improvement						
Changes in inventories						
of which work in progress on cultivated assets						
Consumption of fixed capital						
Acquisitions less disposals of non-produced assets						
Additions to stock levels						
Discoveries						
Reclassifications due to quality change						
Reclassifications due to change of functions						
Natural growth						
Deductions from stock levels						
Extraction of natural resources						
Reclassifications due to quality change						
Reclassifications due to change of functions						
Environmental degradation of non-produced assets						
Other changes in stock levels						
Catastrophic losses and uncompensated seizures						
Degradation of produced assets						
Nominal holding gains/losses						
Change in classifications and structure						
Closing stocks						

4. Accounting entries for specific resources

7.120. Table 7.6 is an elaboration of Table 7.5 with specific entries for each type of asset. The entries are relevant to the following two questions: (a) Can we measure the stock levels in physical terms? and (b) What are the main changes that affect the stock levels? The entries also lay the groundwork for the discussion on valuation in section D.

Table 7.6. Accounting entries for different sorts of environmental assets

	Mineral and energy resources	Soil resources	Water resources
Stock levels	Quantity possible Value possible	Quantity possible Value included in land	Quantity possible (at least partially) Value doubtful, some included with land
Changes due to transactions			
Gross capital formation [Gross fixed capital formation and Changes in inventories]			
Consumption of fixed capital			
Acquisitions less disposals of non-produced assets	Theoretically possible	Included with land	Unlikely except as included with land
Additions to stock levels			
New additions [Discoveries and Natural growth]	Discoveries		Natural inflows, precipitation, returns of abstracted water
Reclassifications due to quality change	Reappraisals (for example, probable to proven)		
Reclassification due to change of functions			
Deductions from stock levels			
Deductions [Extraction of natural resources and Environmental Degradation of non-produced assets]	Extraction	Soil erosion	Natural outflows, evapotranspiration, abstraction
Reclassification due to quality change	Reappraisals (for example, proven to probable)		
Reclassification due to change of functions			
Other changes in stock levels			
Catastrophic losses and Uncompensated seizures	Unlikely	Possible	Possible
Valuation changes	Probable	Included with land	Probably not relevant
Changes in classifications and structure	Possible	Included with land	Possible

Biological resources		Land and surface water	Ecosystems
Cultivated	Non-cultivated		
Quantity possible Value possible	Quantity usually possible Value usually possible	Quantity possible Value possible	Some quantity measure may be possible (for example, area) Value usually possible only as part of the value of a composite asset
Growth (positive) Harvesting (negative) Natural death (negative)		Land improvement	
May be subsumed under harvesting		Decline in value of improvements to land	
Not applicable	Theoretically possible	Occurs regularly	
Possible conversion from non-cultivated status	Growth Possible conversion from cultivated status		Possible
			Possible
		From one land category to another	Possible
Possible conversion to non-cultivated status	Harvesting Natural death		Possible
		From one land category to another	
Possible	Possible	Possible	Possible
Probable	Probable	Probable	Not relevant
Possible	Possible	Possible	

Mineral and energy resources

7.121. In principle, stock levels of mineral and energy resources can be measured in physical terms. This will almost certainly involve expert estimations by geologists and other specialists. Since all mining companies wish to have a good estimate of the size of the deposit on which they are working or at least a good idea of the minimum size, such estimations should, in principle, be available. The scope of mineral and energy stocks in the SEEA is discussed in more detail in section E.

7.122. Additions to stock levels come from new discoveries or reappraisals of the quantity and quality of previously known stocks. Although reappraisals are usually thought of as increasing the stock level, sometimes they may lead to downward revisions.

7.123. Catastrophic losses are fairly unlikely in relation to mineral and energy resources. Flooding of mines is possible but the deposits continue to exist and could in principle be recovered. Fire may destroy an oil well but this contingency is usually well guarded against.

7.124. Valuation changes are regularly observed in respect of subsoil deposits. Changes in ownership, say in moving from the public to private sector, are theoretically possible.

Soil resources

7.125. Measures of soil resources will exist, if at all, in physical terms only, the value of soil being included in the value of land.

7.126. Some extraction may take place from one area for transport to another but it is improbable that this would be significant even within a country and it is even less likely internationally. The most likely entries concern soil erosion, often due to deforestation or overgrazing.

7.127. Major disasters such as flooding or drought can have a significant effect on both the quality and quantity of soil resources.

Water resources

7.128. Not all categories of water resources may be measurable in terms of stock levels, and comprehensive valuations are, at the moment, unlikely.

7.129. The hydrological cycle adds to water supply by river inflows and precipitation and deducts from it by river outflows and evapotranspiration. The other major deduction comes from abstractions for economic use but eventually almost all water so extracted is returned to the environment.

7.130. Traditionally, it has been supposed that the abstraction of water for economic purposes is marginal when compared with the natural recycling of water as it moves down rivers, evaporates and falls again as precipitation. Increasingly, there is concern that the supposition may not be justified, at least at some locations and at some times. This is therefore a case where a supplementary set of physical accounts can be extremely valuable. There is a detailed discussion of the subject in chapter VIII.

7.131. As with soil resources, much interest in water accounts focuses on the quality of water and not just on the physical quantity available.

Biological resources

7.132. Although biological resources grow and yield products through physical processes that are similar for cultivated and non-cultivated resources, they are recorded very differently in the standard economic accounts.

7.133. Stock levels of cultivated resources are measured in both volume and value terms. For non-cultivated resources, either exact measures or reasonable estimates of quantity are likely to be available and valuation will usually be possible. Some exceptions may occur (for example, for fish stocks) but increasingly, in order to monitor the conservation of stocks, detailed estimates have to be made.

7.134. For cultivated biological resources, growth is regarded as output and may enter into stocks as either fixed capital or work in progress. Harvesting and natural death are recorded as negative capital formation. Because of this offsetting of growth by harvest, there is seldom any explicit entry for consumption of fixed capital in respect of cultivated biological assets.

7.135. For non-cultivated biological assets, growth, harvest and natural death will be recorded as additions to and deductions from stock levels.

7.136. Neither sale nor purchase of non-produced assets applies to cultivated resources since they are produced. Either could apply to non-cultivated resources, but this happens infrequently.

7.137. Conversion from non-cultivated to cultivated status, or in the reverse direction for reasons of conservation, is possible. Unforeseen obsolescence is not applicable to biological resources, but catastrophic losses, valuation changes and changes in ownership may be recorded for both cultivated and non-cultivated biological resources.

7.138. In chapter VIII, which presents accounts for forests and aquatic resources, many of these issues are dealt with in greater detail.

Land and surface water

7.139. Generally speaking, the volume of land does not change, though its classification may easily do so. The quality of agricultural land in particular is also subject to change as a result of economic activity. Start- and end-of-year stocks should therefore vary very little if at all in total, though their composition may change.

7.140. Technically, land may emerge through reclamation from the sea, for example, or it may be "improved" by drainage or reclamation from use as a landfill site.

7.141. It is difficult to separate changes in land quality from changes in soil quality and data sources may determine how this is recorded.

7.142. Chapter VIII discusses in detail analyses of land classified by different types of cover and use.

Ecosystems

7.143. These are the most difficult environmental assets to quantify. A comprehensive measurement of all the environmental services provided by ecosystems is conceptually possible but not comprehensively covered by this handbook. Some accounting for the appearance and disappearance of ecosystem features may be possible in a limited form of account.

D. Valuation

7.144. As explained in the introduction, this chapter concentrates on valuation of assets as observed in the market and as recorded in the SNA. It contains a discussion of when the assets may not be separable for purposes of valuation and then explains the principles of valuation in the SNA. It also notes two alternative bases of valuation that are frequently quoted in relation to environmental assets.

7.145. As mentioned in the introduction, those who wish to bypass the detail in this section may go straight to the summary given in subsection 5.

1. Asset classifications of the SNA and SEEA

7.146. In the classification scheme for environmental assets elaborated in section B, each environmental function falls in a different category of the classification. This is entirely appropriate for studies where environmental functions are the main focus of attention. It is difficult to adopt such a precise delineation when valuation is concerned. For some assets, the ambiguity where valuation is concerned is easily apparent. Often the valuation given to a house covers both the building itself and the plot of land on which it is built. The value of a forest may also cover both the value of the standing timber and the land from which it grows. But some aspects of valuation go beyond the assets recognized in the SNA. The value of the forest may include the value of the ecosystems supported by it. The first step, therefore, in considering how to convert physical asset accounts to monetary terms is to look at the interaction between categories of environmental assets in the context of valuation. This is portrayed in Table 7.7.

7.147. For mineral and energy resources, the environmental category includes the SNA category "subsoil assets" and also some deposits that are not included in the SNA either because determining the value of the benefits they represent is felt to be difficult or because no claim of ownership has been established over them. The most common difference between the two classifications will stem from the fact that the SEEA includes and the SNA excludes deposits classed as "probable", "possible", "potential" or"speculative".

7.148. Soil resources present particular difficulties because it is hardly possible to think of valuing the soil of agricultural land separately from the value of the land itself. It is for this reason that the SEEA recommends that soil be measured in physical units only and that its monetary value be included with land.

7.149. Similar arguments apply to surface water. The SEEA asset category EA.13 is treated as being measurable in physical terms only. Monetary valuations of water are included in the categories for land and major water bodies. Both the SNA and the SEEA include "associated surface water" with agricultural and wooded land when it is either not practical or not desirable to try to split either the physical or the monetary measures of two entities so closely linked.

7.150. For groundwater, the resemblance between the SNA and SEEA classifications is similar to that between the categories relating to mineral and energy resources. Established aquifers are treated in both classifications as assets; the SNA does not include aquifers known but of no immediate value because they are too remote or present too many difficulties with respect to extraction.

Table 7.7. Links between SNA and SEEA classifications

SNA classification / SEEA classification		Produced			Non-produced							
		AN.11141 Livestock etc.	AN.11142 Vineyards etc.	AN.1221 Work in progress on cultivated assets	AN.2111 Land under buildings	AN.2112 Land under cultivation	AN.2113 Recreational land	AN.2119 Other land	AN.212 Subsoil assets	AN.213 Non-cultivated biological assets	AN.214 Water resources	Not within the SNA asset boundary
EA.11	Mineral and energy resources								x			x
EA.12	Soil resources				(x)	(x)	(x)	(x)				(x)
EA.131	Surface water					(x)	(x)	(x)				x
EA.132	Groundwater										x	x
EA.141	Timber resources		x	x						x		x
EA.142	Crop and plant resources		x	x						x		x
EA.143	Aquatic resources	x		x						x		x
EA.144	Other animal resources	x		x						x		x
EA.21	Land under buildings				x		x					
EA.22	Agricultural land					x	x					
EA.23	Wooded land		x?			x	x	x		x?		x
EA.24	Major water bodies						x				x	x
EA.25	Other land						x	x				x
EA.3	Ecosystems	(x)	(x)	(x)		(x)	(x)	(x)		(x)	(x)	

(x) Not separately valued.

x? May appear in this box only because of the difficulty of separating it from another asset.

7.151. In principle, land under buildings should be similar in both systems but in practice much of this land in the SNA will appear included with buildings (when, as is typically the case, the building has greater value than the land on which it stands). If it happens that the land has greater value than the building, then the value of this building may appear in the SNA category of land under buildings.) This is one category, though, where in principle there is no land outside the SNA boundary.

7.152. Land under cultivation in the SNA covers all agricultural land and some wooded land in the SEEA. All agricultural land appears in the SNA category of land under cultivation. However, some wooded land may lie outside the SNA boundary, for example, virgin forests too remote for economic use or not subject to ownership. Some wooded land may not appear in "land under cultivation" simply because of the impossibility of separating it from vineyards, orchards, cultivated forests etc. or from the non-cultivated forest resources that subsist on it; therefore, it will appear grouped with those assets.

7.153. Both classifications have a category of other land but the two categories will not correspond exactly because of inclusions and exclusions relating to other assets. The SNA category "recreational land" does not include any land under buildings or cultivation (it is an exclusive if not exhaustive classification) but includes some open public spaces and sports amenities that the SEEA puts in "other land". Because it includes associated surface water, recreational land may also include some water bodies that the SEEA puts in "major water bodies". The SEEA category of other land also includes any non-wooded land that is not covered by the SNA. (In practice, for geographically small or densely populated countries, it is unlikely that any land is excluded from the SNA asset boundary but this may not be the case for large, sparsely populated areas especially where these areas are climatically severe.)

7.154. The SEEA category of ecosystems has no counterpart in the SNA classification and is included in the SNA valuations only to the extent that a valuation of another category automatically includes an element relating to some ecosystem aspect. Recreational land is a case in point but as noted above it may also be the case for non-environmental assets such as buildings also. Some of the techniques to be discussed in chapter IX could in principle be used to put a value on ecosystems.

7.155. Table 7.7 shows the relationship between the 1993 SNA and SEEA asset classifications. The SNA categories may span a number of SEEA headings, for example, different forms of biological assets or different classes of land. Similarly, SEEA assets may cover more than one SNA category (produced and non-produced) or even fall outside the SNA asset boundary; for example, timber resources may be produced by and used in an economic activity (produced assets); may come from nature and be used in an economic activity (non-produced assets); or may not be used in an economic activity (not within the SNA) asset boundary.

7.156. This three-way division of environmental assets will prove to be important in investigating the place of the accounting entries in the SNA sequence of accounts and the principles of valuation underlying these entries.

2. Valuation of assets in the 1993 SNA

7.157. The SNA is unambiguous about how assets are to be measured. If at all possible, market prices are to be used. This is usually possible for produced assets and for land. In some countries, it may also be true for subsoil assets, though this depends to some extent on institutional arrangements. In many European countries, for example, subsoil assets are deemed to be the property of the government and are not sold, hence no market prices exist.

7.158. When market prices do not exist, an alternative is to estimate the net present value of future benefits accruing from holding or using the asset. Economic theory asserts that this is in fact how market prices of assets, are determined. If the value of the future benefits did not at least equal the market price, the asset would not be a cost-effective purchase. Thus, the net present value should be compatible with market prices, although determining the parameters needed to calculate the net present value may be difficult.

7.159. If there are no market prices and it is not possible to calculate the net present value of an asset, then the cost of producing it may be used as a lower bound of its value. Again, the argument runs that it would not be worthwhile to construct the asset unless the benefits were expected to be at least as great as the costs.

Terminology for the use of capital

7.160. A vehicle, building or piece of heavy machinery may be bought by an enterprise to assist in the production process. The items are valued, whenever possible, by the price paid for them on an open market. However, the costs are regarded not as part of intermediate consumption but as ***fixed capital formation***. The reason is that the items provide services over a period of time and are "paid for" over the same period, the life length of the asset in question. Another approach is to regard the asset as disappearing over a period of time by an amount representing the reduction in value of the asset in each year in question. The extent of the disappearance is referred to as the ***consumption of fixed capital*** (CFC).

7.161. The ***gross operating surplus*** of an enterprise represents the ***benefit*** to the owner of using all his assets in the year in question. It can also be described as the value of the flow of ***capital services*** rendered by the assets in the same period or the ***economic rent*** generated by the use of the assets. The value of the assets can, in principle, be estimated by calculating the ***net present value*** (NPV) of the gross operating surplus or economic rent to be generated for each of the future years in which the assets will be still in service. Since a higher value is put on money today than on money in the future, the economic rent for each future year is discounted to reach an appropriate value in today's terms. The discount rate is applied once for each year for which the economic rent is distant. The sum of all the discounted rents throughout the life of the asset is called the net present value of the asset.

7.162. With use, and over time, the value of assets generally declines. Capital services rendered, or used up, entail a decline in value. Set against this is an income element, stemming from the fact that the future benefits have become one year closer and may be called ***the effect on the NPV of time passing***. If the value of the assets at the start of the year is V and the discount rate is r, then the income element can be expressed as rV. For this reason, the income is regarded by economists as representing the ***return to the capital*** used by the firm. For the firm as a whole, this item is the ***net operating surplus***. The decline in the value of the asset is referred to as the ***consumption of fixed capital*** and is the difference between the value of the capital service flows rendered (and thus used up) and the income element that arises in the same period.

7.163. The expressions "gross operating surplus", "net operating surplus" and "consumption of fixed capital" are very familiar to national accountants and are widely used in the SNA. The other formulations come from economic theory but are increasingly being incorporated into national accounting work as evidenced by two recent manuals, one on measuring capital stocks and one on measuring productivity (OECD, 2001a and 2001b). These various concepts are interrelated and different identities can be used to express the inter-relationships (assuming for simplicity's sake at present that there are no taxes or subsidies on production). Because of the interchangeability of the terminology, all these formulations represent the same relationship between the variables. Some of these are spelled out in Box 7.1 for easy reference. The value of consumption of fixed capital can be deducted from gross operating surplus to yield the figure of net operating surplus and from gross fixed capital formation to yield the figure of net fixed capital formation. Almost everywhere in the SNA, the use of the word "net" means that the consumption of fixed capital has been deducted from the aggregate in question. This is true for measures of domestic product and national income as well as for measures restricted to capital only.

Box 7.1. Terminology for the use of capital

Gross operating surplus	= benefit from the asset
	= economic rent
	= value of capital service flows
Net operating surplus	= return to capital
	= effect on the NPV of time passing
	= gross operating surplus *less* consumption of fixed capital
Consumption of fixed capital	= decline in the value of asset between two points in time
	= gross operating surplus *less* net operating surplus
	= gross operating surplus *less* effect of time passing
	= value of capital service flows *less* return to capital

7.164. In certain circumstances, it is possible for either the decline in value of an asset (the consumption of fixed capital) or the return (net operating surplus) to be zero. By convention in the SNA, it is assumed that there is no return to assets used by government for non-market production; therefore, there is no net operating surplus for this sort of production. This is equivalent to assuming a social discount rate of zero for non-market producers.

7.165. If an asset is such that no amount of use in a year leads to a decline in its value, then there is no consumption of fixed capital and the entire value of the capital service flows represents a return to the capital and thus income. In statistical terms, this implies that gross operating surplus and net operating surplus are the same. This used to be held to be the case for such structures as roads, but the 1993 SNA reviewed this practice and suggested that even here there was likely to be some decline in value over time. It is because there is no deduction for the consumption of fixed capital for natural assets in the SNA that all operating surplus earned by them is treated as income. The implication of assuming no decline in the value is that natural growth must always keep pace with harvesting or that the item should be sufficiently abundant as to render it free, with no cost arising from using up such “capital”.

7.166. The identification of how far an asset generates income and how far it is used up in production is crucial for the good measurement of income. Inasmuch as the revenue that results from liquidating assets should not be treated as income, the SNA insists that in principle all income measures in the national accounts should be measured net of consumption of fixed capital (even if this is not always possible in practice for all countries). An insistence on correctly identifying the two elements arising from the use of natural capital is one important reason for moving into the area of integrated environmental and economic accounting.

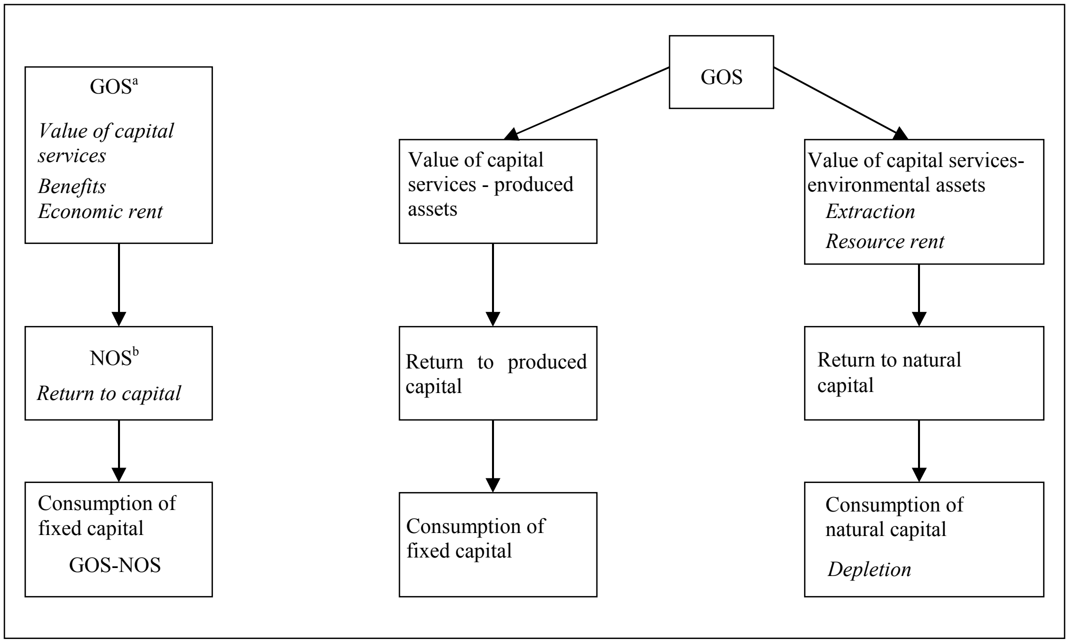
Separating produced and non-produced assets

7.167. If a firm uses both produced and non-produced assets, it is possible in principle to separate gross operating surplus into the capital service flows rendered by the produced capital and those rendered by the non-produced capital. Likewise, it is possible in principle to separate net operating surplus into a return on the produced assets and a return on the non-produced assets. The value of the capital service flows rendered by the natural resources, or their share in gross operating surplus, is the value of the ***extraction***, harvest or abstraction of natural resources. It is also referred to as the ***resource rent***. The term equivalent to consumption of fixed capital is ***depletion***.

7.168. The term “depletion” is commonly used with different meanings. It is sometimes used to denote the total quantity of extractions of natural resources times the realized price per unit. It is sometimes used to represent the net effect of extractions, once the return to natural resources has been taken into account. In the present text, the term “extractions” (and sometimes the term “harvest”, and sometimes both terms) is used in the first sense. Depletion is used, as in the SNA, in the second sense to mean the change in value of the stock of the resource due to extraction. It is thus the counterpart for non-produced assets of the notion of consumption of fixed capital for produced assets.

7.169. Figure 7.1 shows diagrammatically the relationship between the different concepts with the alternative terminology that may be used. The left side of the figure presents the case where all the assets are treated together and the right side presents the case where a separation is made between produced and environmental assets.

Figure 7.1. Decline in the value of fixed capital and the income that it generates



[a] Gross operating surplus.

[b] Net operating surplus.

3. Valuation of non-produced assets

7.170. When there are no direct market prices for non-produced assets, it is necessary to estimate the value using net present value techniques as applied to the resource rent. Once the resource rent for an asset has been determined, three further pieces of information are necessary to determine the net present value (that is, the value of the stock level) of the asset, and are elicited by asking:

For how many more years into the present future will the asset generate economic rent?

What will be the pattern of decline (if any) in the economic rent?

What is the appropriate value of the discount rate that must be applied to earnings in future years?

7.171. For the whole of the present section, it is assumed there is no change in prices during the year. The effect of price changes within the accounting period is discussed in section E where the elements of the asset account relating to "other changes" are discussed.

Estimating resource rent

7.172. There are three possible ways of estimating resource rent. The first is based on actual transactions and may be called the appropriation method. The other two methods of estimation depend on partitioning the information on economic rent for all the assets for a firm into that part pertaining to its produced assets and that part relevant to the non-produced assets.

7.173. There are two basic ways to approach the problem. Both start with the assumption that there is information available on the gross operating surplus (GOS) and net capital stock of a firm or industry. The first method uses the perpetual inventory method (PIM) of determining capital stock to identify the consumption of fixed capital. Deducting this from gross operating surplus gives net operating surplus (NOS). From this an estimate of the return to produced capital is deducted and what is left must be the rent on the non-produced assets. In terms of Figure 7.1, this is equivalent to working up diagonally from bottom left to top right. The second method uses the theory of capital service flows to determine how much of the gross operating surplus represents the capital services rendered by the stock of produced capital. What is then left when this is deducted from gross operating surplus is resource rent attributable to the non-produced assets in use. In terms of Figure 7.1, this is equivalent to working across the first row; from the point of view of calculating resource rent, the lower two rows can be ignored.

The appropriation method

7.174. In many countries, Governments are the primary owner of the nation's natural resources. As landlords, Governments could in theory collect the entire rent derived from extraction of the resources that they own. Resource rent is normally collected by Governments through fees, taxes and royalties levied on companies that carry out extraction. One approach to estimating the economic rent attributable to a resource entails equating it with the fees, taxes and royalties collected from the companies involved in the resource extraction. However, in practice, fees, taxes and royalties tend to understate resource rent, as they may be set by Governments with other priorities in mind, for instance, implicit price subsidies to extractors, and encouraging employment in the industry. Also, the rate of payments to government may not move in line with market prices for the extracted product though one would expect the true economic rent to do so. When these data are not separately identifiable, or suitable, resource rent must be imputed using various indirect methods. However, if the two sets of data are available, publishing a comparison of the values may be useful for economic policy analysis.

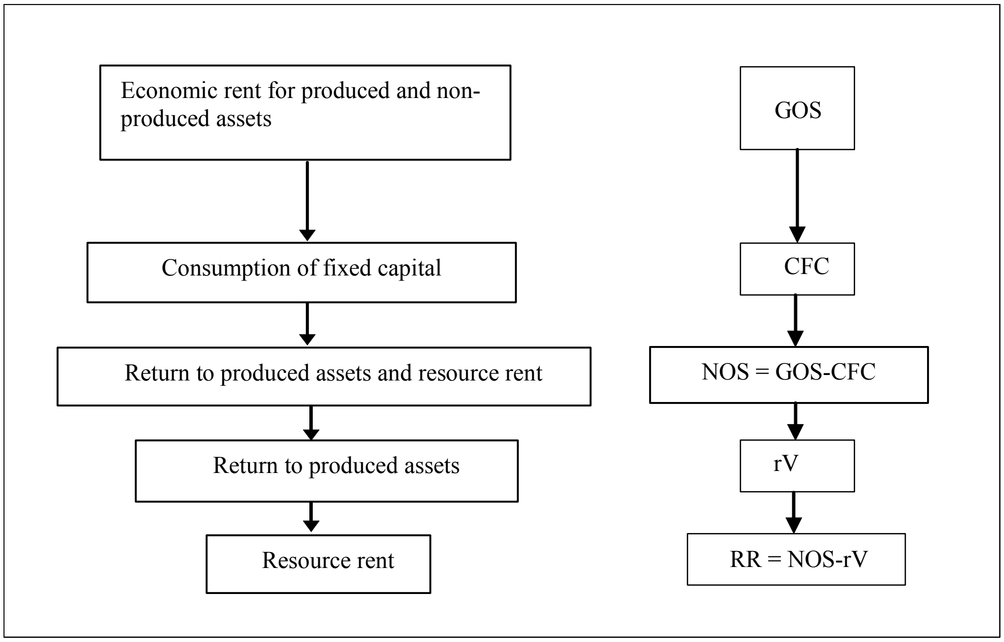
Resource rent derived from PIM calculations

7.175. Many countries use a PIM to determine measures of capital stock. This method starts by determining the value of an asset which is *n* years old by making assumptions about the rate of decline in its value over the *n* years since it was purchased. The decline in this value since the previous year is set equal to the consumption of fixed capital. Net operating surplus is calculated by deducting the consumption of fixed capital from gross operating surplus (from the production account) and the return to fixed capital is calculated using the value of capital stock determined by the PIM. The resource rent earned by the unit, the industry or the whole economy is derived at the end of this sequence of calculations.

7.176. The process to be followed is shown schematically in Figure 7.2. The left side of the figure shows the sequence followed in terms of economic concepts; the right side shows the sequence in algebraic terms.

7.177. Taking the economic rent for all assets, the gross operating surplus (GOS), and deducting the consumption of fixed capital (CFC) gives the return to produced assets and resource rent or net operating surplus (NOS). The return to produced capital is taken to be the discount rate (r) multiplied by the value of the produced capital stock at the start of the year (V). Deducting this from the net operating surplus gives the resource rent (RR).

Figure 7.2. Resource rent derived from PIM calculations



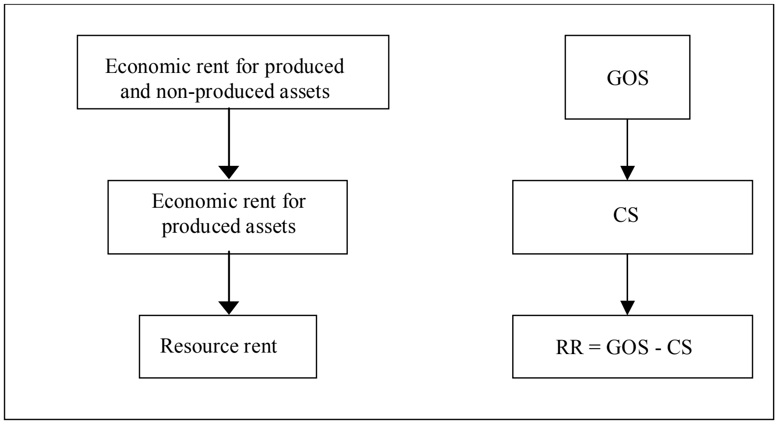
Resource rent derived from capital service flow calculations

7.178. An increasing number of OECD countries are making estimates of capital stocks using the capital service flow method, which is an alternative way of applying PIM. This methodology starts by considering and modelling the decline in the service provided by the asset over its life rather than the decline in price. (A light bulb, for example, may shed the same light throughout its life even though its value declines as it ages because the length of time for which it is expected to function declines.) Such measures of capital service flows are used in productivity studies as well as in the calculation of net income flows. The value of the capital service flows (CS) estimated from the stock of capital is deducted from the total economic rent (GOS) as recorded in the production account. The result gives the resource rent (RR) directly. This is shown schematically in Figure 7.3 both conceptually and algebraically as in Figure 7.2.

7.179. For every pattern of a decline in the service flows provided by an asset, there is one and only one matching pattern of a decline in the asset's price.[24] In theory, therefore, both methods should give exactly the same resource rent. In practice, however, the match between the decline in efficiency and that in price is not always obvious and studies have shown that the capital service flow estimates may be more robust with respect to variations in assumptions than the PIM estimates. More details of producing estimates of capital stocks can be found in a recently published OECD manual on the capital services approach to stock measurement (OECD, 2001a).

[24] This assumes for simplicity's sake that there is no relative inflation in the price of the asset.

Figure 7.3. Resource rent derived from capital service flow calculations



Negative resource rent

7.180. Calculating resource rent as the residual between revenue and costs (operating plus capital) can give very erratic results which may sometimes be negative. One reason is that, for many basic commodities, the price is set on the world market and thus reflects global supply and demand, while the local costs remain fairly constant from one year to the next. If the return to the fixed capital is determined based on a long-run average, then this will give a stable measure of the return to produced capital but a very volatile measure of the resource rent. This issue is discussed further in Born (1995).

7.181. As noted above, and especially when negative resource rents result, it is important to investigate and eliminate as far as possible any fluctuations in the estimates for resource rent caused by errors in methodology or underlying assumptions. Sometimes, though, the fact that the resulting series is erratic and may even be negative on occasion will be correct. This is likely to be the case when it is not possible to make major changes to the rate of extraction for an industry even when the world price drops because of the need to keep machinery operating or because the extractors think the fall in price is temporary and will recover shortly. It may even be the case that an enterprise can afford to extract some deposits only in some circumstances, for example, coal in much of Europe if it is subsidized. In such a case, the economic rent of the coal deposit is clearly zero and the value is also zero. It is only in such cases, though, where there are strong social pressures to continue an uneconomic activity, that exploitation of uneconomic deposits is likely to persist over a period of time.

Zero resource rent

7.182. It should be noted also that if a stock of natural resources is so abundant that no amount of extraction has an effect on the prospective lifetime of the remaining deposit, there is no scarcity of the resource and thus its depletion and the value of the stock are both zero. The whole of the economic rent, or gross operating surplus, represents a return to the capital and thus income. This is the rationale that underlay the accounting for environmental assets in the 1968 SNA (United Nations, 1968), namely, that there was no shortage of resources and thus that it was not necessary to attribute a value to them. On the other hand, it is not sufficient to realize that current extraction procedures may lead to a shortage of some resources in the near future without considering the impact on a nation's wealth and its assessment of its current income. This argument is reinforced by the fact that even a resource that is abundant at the global level may not be plentiful for an individual country or region.

Determining the life length of the resource

7.183. In determining the period over which future extractions or harvests can be carried out, it is indispensable to have physical information available about the existing level of stock, the volume extracted every year and the rate of renewal (if any). The life length of the resource may then be calculated simply as the existing stock level divided by the excess of expected extractions over expected renewals. It is wise to use expected extractions and renewals to allow for exceptional events (say, forest fires expected to occur about every five years on average) and to prevent the emergence of an erratic pattern of life lengths as the life length is recalculated year after year based on new information.

7.184. In the case of renewable resources (that is to say, in practice, biological resources), it is an unambiguous fact that the rate of renewal needs to be included in the calculation of life length.

7.185. If a non-renewable resource is known exhaustively, it is clear that there is no renewal to be taken into account. (An early study of such a case concerned a phosphate atoll. The total size of the phosphate deposit was known very accurately and it was known with equal certainty that there was no prospect of the deposit's being renewed by natural causes on any human timescale.) Life length can be determined straightforwardly from known reserves and expected extraction rates in such a case. The case of other mineral and energy deposits is less clear and the subject of some controversy. The practical problems pertaining to different possible assumptions are discussed at length in the first part of section E below.

Determining the pattern of resource rents

7.186. The demand for and price of the non-produced asset may alter depending on the development of technological alternatives and changing tastes. In the absence of such changes, though, the only factor affecting the pattern of economic rent is the human decision about how much to extract.

7.187. Economic texts show different patterns of extraction to illustrate the impact that these patterns may have on the extractors' revenue and income. In practice, the statistician should base the expected pattern of extraction on past behaviour, informed by expert information if such is available. In the absence of any other information, it is probably safest to assume that extraction will continue at the same rate as in the past, since this is the level for which an appropriate level of fixed capital has been acquired.

Determining the discount rate

7.188. As discussed above, resource assets for which returns are either delayed (growing timber) or spread over a lengthy period of time (mineral deposits) can be valued by discounting the expected future income to a present value. Doing so first requires the choice of a discount rate, a choice that is often the subject of considerable debate.

7.189. The discount rate (that is, the rate used to discount future income) reflects a time preference: the preference of an asset's owner for income today rather than in the future and also the owner's attitude towards risk. These factors will vary depending on the ownership of the asset. In general, individuals and businesses will have higher rates of time preference than Governments, that is, individuals and businesses will tend to demand a quicker return from ownership of a resource asset than will Governments. Higher rates of time preference translate into higher discount rates. Higher degrees of risk aversion will also lead to higher discount rates.

7.190. Some commentators argue that "social" discount rates should be used to derive the net present value of non-produced assets. The rationale is that these rates take into account inter-generational issues which suggest the discount rate (time preference) should be closer to zero.

Determining the rate of return

7.191. As discussed above, the return to an asset is that part of value added, specifically part of net operating surplus that can be attributed to the use of the given asset in production. The rate of return is a ratio, usually shown as a percentage, which relates this income flow to the value of the stock that generates it. The simplest way of calculating such a rate is therefore to divide the return to the asset by its capital value.

7.192. This simple ratio, however, assumes that the value of capital stock covers all the assets used in production or, put another way, that there is no income arising from assets which have not been included in the measures of capital stock. If there are such assets, then the rate of return will be overstated because returns to unidentified assets will be attributed to those that have been identified. Obviously the issue of greatest interest in this handbook is the identification of the value of natural assets used in production, but it is worth remarking that there are serious concerns about other types of assets which may be captured either poorly or not at all. One example of these is so-called intangible assets such as those associated with trademarks and brand names. Another concerns the role of education and training in enhancing human capital.

7.193. The means of identifying the part of operating surplus attributable to these sorts of assets is to use an exogenous rate of return for the identified assets and treat the rest of the operating surplus as the return to the unidentified assets. This is the basis of two of the three means of estimating resource rent described above. Sometimes, however, an exogenous rate of return will be applied even when it is thought that all assets have been identified and correctly valued to determine “normal profits” for the enterprise in question. Any difference from net operating surplus as calculated in the production account is described as “pure profit” or “pure loss”, depending on sign. It is usually assumed that a pure profit exists only when there is some distortion on the market, for example, when a new product is first launched and can command a premium on its price.

7.194. There are at least three views about how to determine an exogenous rate of return. The first is that it is determined by the net operating surplus generated from the capital stock of the particular industry in question. Or, the return to produced capital could be seen as covering the cost of financing the acquisition of the produced capital stock. Alternatively, it can be interpreted as the opportunity cost of the investment in the produced capital assets. This opportunity cost could be estimated as the average real rate of return on investment elsewhere in the economy.

7.195. In the first approach, the concept of a “normal” rate of return is often applied to the value of fixed capital stock. This normal rate is sometimes determined by reference to the ratio between net operating surplus (rate of return) and capital stock in an industry that is assumed to have similar performance characteristics but without the presence of a natural resource.

7.196. The second approach assumes the interest rate on bonds issued by resource companies or the return on shares in resource industries is appropriate for use as the rate of return. The financing cost approach has the advantage that the returns are directly related to the risks associated with the operation of the capital (in the case of the bond price). However, returns on shares reflect returns both on capital and on the resource, besides being influenced by external factors in the market. Therefore, while the use of the rate of interest on bonds seems appropriate as a proxy for estimating returns on capital, the use of return on shares does not.

7.197. The third approach relies solely on the opportunity cost of capital elsewhere in the economy. An interest rate based on long-term government bond rates is taken as the value of the rate of return for use in estimating the return to produced capital in the accounts. The disadvantage of the long-term government bond rate as an appropriate "return to capital" is that it is a "riskless" rate. The rate does not include a premium to cover the risk and uncertainty involved in extractive industry operations.

7.198. The first and second approaches attempt to approximate the internal rate of return, whereas the third is clearly an external rate that, it is supposed, should hold more generally. The rate of return on corporate bonds could be used to derive returns on capital in the particular industry under consideration. Where there are few corporate bonds issued in the country that is compiling asset values, then any of the three approaches may be adopted, provided an allowance is made for countering the deficiencies in the approaches.

Relationship between the discount rate and rate of return

7.199. In an enterprise where all the assets are identified and measured accurately, and where conditions of perfect competition prevail, the discount rate and the rate of return should be equal. If the discount rate is higher than the rate of return to capital, the entrepreneur would be advised to lend money rather than invest in more equipment. If the rate of return is higher than the discount rate, there will be a shortage of funds to lend and the discount rate should rise to attract more funds. Ultimately, both rates depend on the opportunity cost of capital and the time preference of the asset owners for money now or in the future.

7.200. As noted above, however, there are several reasons why this equality may not hold. When the extractor and the owner are two different units with different time preferences and attitudes towards risk, a difference between the two rates can be justified. However, wide and persistent differences between the two rates should be examined for plausible explanations. It is important for the statistician to try to ensure that errors of measurement are eliminated as far as possible and, to this end, alternative estimates of resource rent and the calculation of "pure profits" may be helpful in establishing confidence in the estimates to be used in calculations depending on resource rent.

Nominal and real rates

7.201. Net present value calculations express future incomes in terms of the prices at a given point in time. If the time series of rents to be discounted and added is expressed in constant prices, the discount rate or rate of return should be a real rate (that is, one from which the general level of inflation has been removed). If the time series of rents is expressed in prices with a built-in level of inflation, then the rates used must also allow for this inflation so that the process of discounting removes the effect of inflation as well as brings the valuation back to one at the date of interest.

7.202. Usually, the models underlying both the PIM and the capital service flows approach are calculated in constant prices, in which case the discount rate should be in real terms (that is, adjusted for the general rate of inflation). However, if future rents are estimated allowing for price inflation, then the same level of price inflation should be allowed for in the discount rate used. Ambiguities arise if different rates of inflation are allowed in the different elements in the calculations.

4. Estimating the value of the stock level of the resource

7.203. Once estimates for the life length of the asset, the resource rent over this period and a discount rate have been determined, the value of the stock level of the resource can be estimated as the net present value of the pattern of resource rents.

7.204. Using the approach above, gross or net operating surplus can be divided into one part attributable to produced capital and one part to resource rent. Where making projections into the future is concerned, the relative life lengths of the two sets of assets must be considered. If they are identical, the value of the stock of the resource may be written as either the net present value of the series of (GOS_t -CS_t) or (NOS_t-rV_t). There is yet a third way of writing this. The net present value of (GOS_t-CS_t) may be written as the net present value of *GOS* less the net present value of C*S*. By definition, the net present value of *CS* is the value of the produced capital stock*, V,* so the value of the stock level of the resource may be written as any one of the following:

$NPV(GOS_t - CS_t)$

$NPV(NOS_t - rV_t)$

$NPV(GOS_t) – V$

7.205. In all these equations, the calculation is over the life length common to both sets of assets. If the natural resource has a life length greater than the produced capital in place to extract it, while the NPV formula needs to be applied to the whole of the life of the natural resource, then the available series for capital services rendered by the produced assets and the return to these will exist only for a shorter period corresponding to the life of the produced capital. In this case, projections of capital services arising from additional produced capital and the return to it, or the present value of future capital formation, must be made and incorporated in the appropriate equation.

The net price or Hotelling alternative

7.206. An alternative sometimes offered to the net present value method described above is the net price method based on the Hotelling model. This model assumes that under certain market conditions non-renewable resource rent will rise at a rate equal to the rate of discount (or interest rate) as the resource becomes scarce.[25] Under these circumstances, the value of the resource stock can be calculated simply as the current rent per unit of resource times the size of the stock (Landefeld and Hines, 1985). Because rent rises over time at a rate that is exactly sufficient to offset the discount rate, there is no need to discount future resource income.

7.207. Implicit in the calculation is the assumption that the net price of the resource rises in line with the rate of discount. The evidence to support this approach is mixed. Further, a question may be asked whether an estimate based on the assumption of future price increases is consistent with normal SNA valuations for balance sheets when the prices of the balance sheet date are used for valuation throughout.

5. Summary of methods for valuing natural resource stocks

7.208. Box 7.2 gives a summary of the factors discussed in this section that determine the value given to natural resource stocks. The following section considers how these general considerations apply in the case of particular assets.

[25] The Hotelling model is generally assumed not to apply to renewable resources, which, if sustainably managed, do not become scarce. Renewable resources that are not sustainably managed, but depleted instead, can in theory be valued using the Hotelling model.

Box 7.2. Summary of methods for valuing resource stocks

Data needs for estimating ***stock values***

- Resource rent
- Stock of the resource
- Life length or rate of extraction of the resource
  - *Decision on how to record renewals/discoveries*
- Discount rate for future income

Data for estimating ***resource rent***

1. Appropriation method
   - Direct observation
2. PIM-based method
   - Stock of produced capital (estimated from price decline)
   - Net operating surplus
   - Rate of return to produced capital
3. Capital service-based method
   - Stock of produced capital (estimated from efficiency decline)
   - Gross operating surplus
   - Capital services rendered by produced capital

Simple definitions of key terms

Appropriation	Observed payment of (part of) resource rent to the owner of the resource.
Capital services	A measure in volume terms of the services rendered by an asset in an accounting period.
Capital services method	A means of estimating the total volume of services rendered by all assets formed by aggregating the capital services of a group of assets.
Consumption of fixed capital	The decline in the value of an asset (other than the effect of price changes) due to its use in production during the accounting period.
Discount rate	The annual percentage by which future income is discounted to give an equivalent value in the present period.
Economic rent	The income generated by an asset when used in a production process.
Gross operating surplus	The difference between the value of an enterprise's output less all costs of production including compensation of employees and any taxes on production. It is conceptually equal to the sum of the economic rent of all assets used.
Life-length	The period of time for which an asset is expected to remain of use. For natural resources, this is often calculated as the stock divided by the average annual (net) extraction rate.
Net operating surplus	Gross operating surplus less consumption of fixed capital.
PIM (perpetual inventory method)	A method to determine the level of the stock of one or several assets by cumulating acquisitions and deducting disposals and the decline in value due to the use of the asset in production.
Rate of return	Measures the "profitability" of an asset. Often calculated by dividing the operating surplus by the capital stock.
Resource rent	The economic rent of a natural resource.
Stock of an asset	The level of the resource available. It can be measured in both physical and monetary terms.

E. Asset accounts in monetary terms

7.209. The present section discusses the valuation of stock level of a number of individual natural resources as well as the means of valuing additions to and deductions from stock levels, with separate subsections for mineral and energy resources; biological resources, both cultivated and non-cultivated; and land and soil. Some mention is made of the problems of valuing water and ecosystems, though at the present time it is unlikely that comprehensive asset accounts in monetary terms can be established for these assets.

7.210. There is also a subsection discussing the problems associated with establishing values for the other changes in assets, especially the effect of price changes.

1. Mineral and energy resources

7.211. Valuation of mineral and energy resources, frequently equated with subsoil deposits, is complicated by the means of recording associated investment in produced assets. The special cases of the measurement of mineral exploration and the relationship of mineral exploration to the valuation of new discoveries are discussed at length in chapter VIII. The issue of decommissioning large extractive structures such as oil rigs is also relevant. This was discussed in chapter VI and is referred to again in chapter VIII. In the present section, it is simply assumed that these problems have been resolved and all that remains is to estimate the value of the subsoil deposit itself.

7.212. Sales of subsoil deposits do sometimes take place, albeit infrequently, and the information on market prices for them may thus be very limited. The extent of information available may depend on institutional arrangements. For countries where the subsoil deposits are held privately, there is likely to be more information on sales than in countries where all subsoil deposits are owned by the government. In practice, therefore, the value of the stock level of mineral and energy resources will often be estimated by means of the net present value techniques described in the preceding section. Estimates are needed for the unit resource rent to be used, the physical level of stocks, the rate of extraction and the discount rate to be used.

7.213. As explained in the previous section, the value of a stock of a natural resource can be calculated as the net present value of the stream of future resource rents that the resource will yield until it is exhausted. This resource value (RV) can be written as a function of the resource rent (RR), the years the resource is expected to last until exhaustion (n) and a discount rate (r). For minerals and subsoil deposits, if no better information is available, it is often assumed that the rate of extraction will be constant from year to year. In such a case, the value of the resource rent will stay constant in constant price terms and the value (also in constant price terms) can be written as

$$RV = RR\sum_{k=1}^{n}\frac{1}{(1+r)^k} = RR\left[\frac{(1+r)^n - 1}{r(1+r)^n}\right]$$

If the level of the stock of the resource in physical terms is S and the annual rate of extraction in the same units is E, then the life length of the deposit, n, is simply

$$n = S/E$$

Similarly, the unit resource rent rr can be written as

$$rr = RR/E$$

Thus, the value of the stock of the resource depends on the physical stock level (S), the annual extraction (E), the unit resource rent (rr) and the discount rate (r). Each of these is discussed in more detail below.

Stock level

7.214. Originally, in calculating life length of oil reserves, it was assumed that since the reserves were not renewable on a human timescale, the appropriate estimate of life length would be simply proven reserves over current extraction rate. On this basis, several European countries have had 10 years worth of oil stocks for over 20 years. Calculating the value of the stock on this basis and speaking of running down the nation's wealth over a 10-year period is then misleading.

7.215. Estimates of the physical stocks of subsoil resources, especially oil and gas, are usually categorized by the degree of certainty with which they are known and their economic viability given present prices and extraction technologies. Deposits that are well described and viable are often described as "proven" and those where there is less certainty as "probable". These terms are not exact and are subject to variation from one country to another. Further discussion of the measures of physical stocks is given in chapter VIII. For the purposes of the present chapter, it is sufficient to use the categories of proven and probable as just described.

7.216. The SNA specifies that the coverage of subsoil resources is to be valued in the balance sheet as proven reserves only. A number of countries work, even in the SNA context, with proven plus probable reserves rather than with proven only, sometimes because the information on the two classifications is not available separately and sometimes simply because a more realistic assessment of "established" reserves is required. One possibility is that probable reserves should be added to proven reserves with a weighting factor reflecting the probability of their being converted to proven and even to extend the same procedure to possible reserves (with a lower probability factor). Though theoretically appealing, this process is likely to encounter data problems in implementation. The simple use of proven plus probable seems a preferable, generally applicable recommendation for the SEEA.

7.217. In principle, the coverage of the reserves in the physical and in the monetary asset accounts should be the same if the two accounts are to be used in combination. In the SEEA, both proven and probable reserves are included as assets but, as just noted, countries following the SNA strictly will cover only proven reserves. In such a case, it would be helpful if the valuations in the SEEA accounts were separated by type of reserves so that the degree of overlap with the SNA could be obvious.

Resource rent

7.218. Historically, the unit resource rent for subsoil assets varies from year to year. Since it is calculated in effect as a residual, if the world price of oil rises faster or more slowly than the costs of extraction, other things being equal, the resource rent will fluctuate in the same direction. Projections made about the level of unit resource rent over a future period usually assume that it will remain constant in constant price terms. The question that remains is whether to use the unit resource rent observed in the most recent period, or an average over a number of recent years, or to make projections building in assumptions about the likely evolution of relative prices over the period in question. This issue is discussed further in the section on prices below.

Extraction rate

7.219. Independently of assumptions about the unit resource rent, an assumption must be made about the pattern of extraction to be followed over the course of the future. The assumption most often used is that it will stay constant in physical terms, but there is no reason why this should necessarily be so. As resources approach extinction, there may be a decline in output as some deposits become completely exhausted if there are no new deposits to take their place. Alternatively, an enterprise could adjust the rate of extraction to give the same total income every year, or could reduce the amount extracted as the resource diminishes, assuming that the price increased at the same time. There may be information available from government or from enterprises on projected levels of extraction that could be used. However, these often tend to be based on conservative projections of the likely level of new discoveries and reappraisals. Hence, the published figures on the expected life length of resources are regularly exceeded in practice. For simplicity's sake and in the absence of more precise information, the assumption made here is that the rate of extraction is kept constant in physical terms.

Life length

7.220. At any point in time, the life length of the reserve is equal to the stock at that point divided by the average extraction rate. In the course of a year, the life length will diminish by one due to extractions and will change by D/E where D is the level of new discoveries and reappraisals and E the average extraction rate. If D is positive, then the life length increases; if on balance there are more negative reappraisals than upward reappraisals and new discoveries, then the life length is further reduced in the course of the year. The life length at the end of the year, n_t, can thus be expressed as the life length at the beginning of the year, n_{t-1}, less one due to extractions, plus D/E. Thus, both extraction and discoveries affect the life length at the end of the period but not the life length at the start of the period. To convert from the start-period life length, therefore, it would be necessary to make a projection of the likely level of discoveries as well as assume that the life length will be diminished by one year due to extractions.

7.221. Obviously, the extent of the stock used to calculate life length must be consistent with the extent to be valued. If a value is to be placed on proven reserves only, then the life length will be appreciably shorter, and the value of the stock lower, than if proven and probable reserves are to be used together. Given that extractions are always made from proven reserves, one way of looking at this is to say that the proven reserves give a life of, say, n_1 years, the probable reserves extend this from year n_1+1 to n_2 and possible reserves (if counted) extend the life further from year n_2+1 to n_3. Given the way in which the discounting factor increases, this automatically means that the more distant the prospect of extraction, the less the reserves of equal size contribute to the present monetary value. This does not necessarily imply that the newly discovered reserves are extracted last, but simply that some of the combined existing and newly discovered reserves will be extracted in these later years.

The valuation of discoveries

7.222. The value of discoveries is the amount by which the NPV of the whole deposit increases as a result of new finds and upward reappraisals. The additions should be added to any existing volume estimates of proven plus probable reserves, with the same rate of extraction and the same discount rate as for the initial volume. The value of discoveries is then the difference between the NPV of the enlarged volume and the volume before the new discoveries. If the life length of the reserves before the discovery was n years and after discovery it is $n+t$ years, then the increase in value is the NPV of extraction in years n+1 to $n+t$. The addition to value of the discoveries is much smaller than the value of a similar quantity of resources at the time of extraction, and very much lower than the market price for the extracted resource. Further, the value of the discoveries also depends on the level of existing proven reserves. If these are high, the value of the discoveries is lower than the value of the same volume when existing proven reserves are lower or zero, reflecting the relative scarcity of reserves in these two cases.

7.223. If the size of the discoveries is so large that the average level of extraction permanently increases, then there will be consequent changes in the value of the total resource stock on this account.

Valuation related to parameter changes

7.224. Because the value of the reserve stock depends on the stock level, the extraction rate and the unit resource rent, it is possible to consider the effect on the value of changes in the stock level due to extraction, due to changes in the extraction rate, due to discoveries and due to changes in the unit rent. Suppose that in addition to the value at the end of the year, RV_t, values under three other conditions are considered, denoted by subscripts 1, 2 and 3 and the variables relating to the previous year have subscript t-1. The difference between the end-of-year point t and condition 1 is the level of discoveries, D_t. Between conditions 1 and 2, the difference is the extraction E_t. Between conditions 2 and 3, it is the extraction rate that changes, to E_t from E_{t-1}. Between condition 3 and t-1, the start of the year or, equivalently the end of the previous year, it is the unit resource rent rr_t that has changed, from rr_{t-1}. This is shown schematically in Table 7.8. This scheme simplifies the timing of events by assuming that the unit resource rent and the rate of extraction change at the start of the year and that discoveries and rent are recorded at the end of the year.

Table 7.8. Parameters for valuation under different assumptions

Value	Subscript	Unit resource rent	Extraction rate	Stock level	Life-length
RV_t	t	rr_t	E_t	$S_t = S_{t-1}-E_t+D_t$	$n_t = S_t/E_t = (S_{t-1}-E_t+D_t)/E_t$
RV_1	1	rr_t	E_t	$S_{t-1}-E_t$	$n_1 = (S_{t-1}-E_t)/E_t = n_2-1$
RV_2	2	rr_t	E_t	S_{t-1}	$n_2 = S_{t-1}/E_t$
RV_3	3	rr_t	E_{t-1}	S_{t-1}	$n_3 = n_{t-1} = S_{t-1}/E_{t-1}$
RV_{t-1}	t-1	rr_{t-1}	E_{t-1}	S_{t-1}	$n_{t-1} = S_{t-1}/E_{t-1}$

7.225. The change in the value of the stock over the whole year is RVt-RVt-1. This can be decomposed into a number of stages in each of which only one of the parameters changes, thus

$$RV_t - RV_{t-1} = (RV_t - RV_1) + (RV_1 - RV_2) + (RV_2 - RV_3) + (RV_3 - RV_{t-1})$$

7.226. Box 7.3 shows how each of the expressions affects the total value of the stock of the asset. Putting all these together, the total change in the value of the stock of the resource between the start and the end of the year can be decomposed as shown into five elements:

Effect of discoveries and reappraisals

Effect of extraction

Return to the natural resource (effect on the NPV of time passing)

Effect of changing extraction rate

Effect of changing resource rent

Of these, the first and the last two may be zero but the other two will always coexist and always exist as long as any extraction takes place.

7.227. Note that this decomposition is dependent on the order in which the effect of the changes in parameters is evaluated. A different ordering will give somewhat different results.

Box 7.3. Derivations of the decomposition of change in stock valuation

Discoveries and reappraisals (RV_t-RV_1)

Supposing the discoveries are positive, then the new life length n_t is greater than n_1 and this expression can be written as

$$RV_t\text{-}RV_1 = rr_t E_t \sum_{k=1}^{n_t} \frac{1}{(1+r)^k} - rr_t E_t \sum_{k=1}^{n_1} \frac{1}{(1+r)^k}$$

$$= rr_t E_t \sum_{k=n_1+1}^{n_t} \frac{1}{(1+r)^k}$$

$$= \frac{rr_t E_t}{(1+r)^{n_1}} \sum_{k=1}^{n_t - n_1} \frac{1}{(1+r)^k}$$

If there are net negative reappraisals, then n_t is less than n_1 and the expression becomes

$$RV_t - RV_1 = \frac{-rr_t E_t}{(1+r)^{n_t}} \sum_{k=1}^{n_1 - n_t} \frac{1}{(1+r)^k}$$

If there are no discoveries in the year, n_t is exactly equal to n_1 and the term for RV_t-RV_1 is exactly zero.

Extraction (RV_2-RV_1)

The value of the stock after deducting E_t from the previous stock level, can be written as

$$RV_2 = rr_t E_t \left[\sum_{k=1}^{n_2} \frac{1}{(1+r)^k} \right] = \frac{rr_t E_t}{1+r} + \frac{rr_t E_t}{1+r} \left[\sum_{k=1}^{n_2 - 1} \frac{1}{(1+r)^k} \right]$$

$$= \frac{rr_t E_t + RV_1}{(1+r)}$$

and so

$$RV_1 - RV_2 = -rr_t E_t + rRV_2$$

Thus the change in value due to extractions in a year can be expressed as the sum of a decrease equal to the value of the resource rent and an increase equal to the return on the value at the start of the year. This is a more formal derivation of the equation described in Figure 7.1.

Changes in the extraction rate (RV_2-RV_3)

Changing the extraction rate changes the expected life length and is similar in its impact to discoveries and reappraisals, but with the unit resource rent unchanged, the total stock value alters as follows:

$$RV_2 - RV_3 = rr_t E_t \sum_{k=1}^{n_2} \frac{1}{(1+r)^k} - rr_t E_{t-1} \sum_{k=1}^{n_3} \frac{1}{(1+r)^k}$$

$$= rr_t E_t \left[\sum_{k=1}^{n_2} \frac{1}{(1+r)^k} - \frac{E_{t-1}}{E_t} \sum_{k=1}^{n_3} \frac{1}{(1+r)^k} \right]$$

Change in the unit resource rent (RV_3-RV_{t-1})

$RV_3 - RV_{t-1}$ represents the change in value due to a change in resource rent:

$$RV_3 - RV_{t-1} = rr_t E_{t-1} \sum_{k=1}^{n_{t-1}} \frac{1}{(1+r)^k} - rr_{t-1} E_{t-1} \sum_{k=1}^{n_{t-1}} \frac{1}{(1+r)^k}$$

$$= E_{t-1} \sum_{k=1}^{n_{t-1}} \frac{1}{(1+r)^k} \left[rr_t - rr_{t-1} \right]$$

7.228. Table 7.9 gives an example of such a decomposition for Norway for 1995. The life length for the resource at the beginning of the year was 25 years.

Table 7.9. Decomposition of changes in oil reserves

	Volume (millions of tons)	Value (billions of Norwegian kroner)
Opening stocks	3 531	418
Discoveries and reappraisals	116	8
Extraction (resource rent)	-141	-26
Return to natural capital		16
Change in the rate of extraction		13
Change in the unit resource rent		-18
Closing stocks	3 506	411

Source: Statistics Norway.

Aggregation of the same resource over different deposits

7.229. In the discussion so far, it has been implicitly assumed that the mineral and energy resources constitute a single deposit, so that any extractions and discoveries affect the life length of all reserves available to a country. In practice, of course, this is not the case: some oil fields will be exhausted in a relatively short time frame and extractors will then move to another. The question arises, therefore, whether it is legitimate to calculate the value of all resources as if they were in a single deposit or whether they should be calculated field by field.

7.230. Many reappraisals apply to established fields where extraction is already in progress. New upward revisions in quantities will extend the life of the wells and, by analogy with the "first in, first out" model of depletion of inventories, the addition to value will reflect the previous and new life lengths. As long as the initial calculations are correct, the adjustments for changes in the life length will also be realistic.

7.231. A somewhat different situation holds for a completely new discovery. If a new field is discovered with an expected life length of, say, 20 years, equal by itself to the existing reserves of a country, it is not realistic to automatically assume that this new field will be extracted in years 21 to 40. On the other hand, neither is it realistic to automatically assume that it will be extracted in years 1 to 20 and thus double the total extractions in these years. It always takes a little while to prepare for extraction thus there is a built-in delay initially. Further, in cases where there is such a large new discovery, the impact on the rate of extraction of pre-existing reserves should be taken into account explicitly. For these reasons, it is desirable, if at all possible, to make projections of the impacts of new discoveries and reappraisals separately.

Disaggregation of different resources occurring in the same deposit

7.232. For some subsoil resources, a single deposit may yield several products. An oil well often contains gas also. Silver, lead and zinc frequently occur together and can be extracted only together. In this case, the resource rent used in the calculation of the value of the resources needs to be divided by commodity. However, in practice, data are available by establishment only. In such cases, a separation of the unit costs of extraction for each product is not possible except by using some rule of thumb.

7.233. One possibility is to allocate total extraction costs in proportion to each product's contribution to net revenue from the mine. If no extraction cost data at all are available, then extraction costs may be estimated by pro-rating total operating expenses between extraction and non-extraction costs. This may be done by asking a sample of mining companies what they expect the breakdown between operating and extraction costs to be. Once this is done, net revenue data is then used as an indicator to derive extraction costs by commodity. As a final option (if the above solutions are not possible), costs could be estimated by commodity by assuming a ratio of extraction cost/price for each commodity.

7.234. Sometimes production processes, such as extraction and refining or mining and raw metal processing, are integrated. In such cases, it is difficult to identify separately the extraction costs from all the other costs. In the case of integrated production processes, the extraction activity is likely to be treated as an ancillary activity. In this case, the value of the extracted products used internally is not a part of the reported value of production. The costs for the extraction activities are included in the total cost of the enterprise, but the part of the total cost that is related to the extraction is not separately specified. If detailed data are available from the enterprise, it may be possible to assess incomes and costs associated with the extraction activity. Alternatively, it may be necessary to impute the resource rent from the combined activities of the enterprise, assuming that all profits above the "normal" return to capital are due to the use of the subsoil assets.

2. Biological resources

7.235. Biological resources are divided into cultivated and non-cultivated resources.

Cultivated biological resources

7.236. Cultivated biological resources are valued according to standard SNA rules. This means that observed prices are the preferred method of valuation. For these resources, observed prices are generally available.

7.237. For beef cattle or crops, all the costs incurred in cultivation are recorded as production and capital formation (specifically, increases in inventories) until the time of slaughter or harvest when decreases in inventories are recorded. The rationale for this treatment is the fact that rearing plants and animals is a production process with a long production period. All costs are cumulated as a form of capital cost until the moment when these can be recovered via the sale of the crop or animal.

7.238. In the case of a dairy cow or rubber tree, for example, the market price is assumed to be equal to the discounted present value of the future yield of milk or rubber over the life of the cow or tree. Production and fixed capital formation are is recorded in the early years of the life of the cow or tree as it reaches maturity and consumption of fixed capital as it declines from its peak of maturity. These effects are reflected in the prices for animals and plantations of different ages.

7.239. The value of the stock of cultivated biological resources is relatively simple to calculate as the observed market price per unit times the volume of the stock, allowance being made for the fact that prices for assets of different ages carry different prices. Only for plantations yielding repeat products over a period of time is it likely that NPV techniques for valuation will be necessary.

Non-cultivated biological resources

7.240. For non-cultivated biological resources, the basis of valuation is the resource rent only. The resource rent is derived by deducting all costs of harvesting the resource from the market price received for it. The value of the stock is then derived by NPV techniques using information about the total physical quantity, its expected life length given natural growth rates, and the rate of harvesting.

7.241. In principle, additions to stock levels should be recorded for natural growth (less natural wastage) and deductions from the stock levels should be recorded for the harvesting that takes place for human consumption. In some cases, though, it may not be possible to record these separately but only the net change in stock levels.

Wooded land and timber resources

7.242. In the asset classification of the SEEA and the 1993 SNA, forest land and standing timber are classified as two separate assets. Land is a non-produced asset, while standing timber is a produced asset if the forest is cultivated and a non-produced asset if it is non-cultivated.

7.243. In principle, the value of timber and the value of forest land should be separated. In practice it is often difficult to separate the two elements since forested land may not be available for other purposes, whether by reason of location, soil type or administrative restrictions. When looking at a forest as an indefinite "going concern", the value to be given to it clearly covers both the land and the standing timber. This composite asset is called a "forest estate" here to distinguish it from forested land, forests and standing timber. It should also be taken to include any forest-related environmental assets included in the area concerned.

7.244. A range of methods have been developed and tested to value forest estates as well as land and standing timber separately. Eurostat has published a manual presenting a framework for integrated environmental and economic accounts for forests (Eurostat, 1999) as well as a report on valuations performed testing this framework (Eurostat, 2000b). The Food and Agriculture Organization of the United Nations (FAO) is in the process of compiling a handbook devoted entirely to the compilation of forest accounts.

Forest estates

7.245. A simple method for valuing forest estates is to calculate the average price of one hectare of forest and to apply it to the whole forest area. Average prices may be calculated from a register of transactions or a fiscal database. Data on transactions exist in many countries but the number of transactions per year is often very low. Many transactions that do take place may be influenced by hunting rights and questions of inheritance as much as by pure forestry-related motivations. Sales following the reclassification of forest land (for example, to permit road-building) may also influence recorded prices. Thus the use of transaction data as a source may not be wholly suitable without further examination.

7.246. As forests are often not homogeneous, if the data are available, it is preferable to classify forests according to their characteristics and to then calculate a price for each category and apply this price to the corresponding stock. Relevant classification criteria are the productivity of the land, the species and age structure of the standing timber, the existence of hunting rights and so on.

7.247. Starting from a sample of recorded transactions, the value of forest estates can also be estimated as a function of these characteristics using a hedonic pricing model. This method can be used to value forest land and standing timber separately by associating the characteristic used to one or the other underlying asset.

7.248. Another tool that can be used to value forest estates is the net present value of the future forest resource rent. The resource rent is calculated as the value of output in the forestry industry minus all costs of production. The production costs include a return to produced fixed assets engaged in production (roads, buildings, equipment etc.) and compensation to self-employed persons. If the current level of harvesting is assumed to be sustainable, and prices and costs are assumed to be constant, the value of the forest may be calculated as the present value of a constant, perpetual stream of resource rent generated by the harvesting.

7.249. Comparing the results of the transactions-based method and the net present value method can offer insights into the validity of the assumptions used in the estimates, including the discount rate used and the biases in observed transactions prices.

Forested land

7.250. In some countries, transaction prices of bare forest land are available and can be used to value the whole forest area in a similar way to that described for forest estates. If this is not the case, it might be possible to estimate land values based on transactions in forest estates using hedonic pricing techniques as described above.

7.251. The price of bare forest land may also be approximated according to the price of comparable land starting, for example, from prices of marginal agricultural land. Other alternatives are to estimate the price of land as a share of the price of forest estates or to use recommended (administrative) values.

7.252. Another possibility is to apply two different valuations to the standing timber on the forested land. The first values the standing timber at a moment in time, assuming that no regeneration will take place as trees mature and die or are felled; in other words, harvesting of timber is restricted to the current rotation cycle of the forest. This puts a value on the existing standing timber. The second valuation is on the basis that harvesting can be sustained indefinitely, so that the value of the asset can be calculated as the discounted present value of an indefinite annual stream of rent generated from harvesting the timber stock. As explained above, this gives a valuation of the timber and land combined as a forest estate. The differences between these two estimates can then be taken as an estimate of the forested land excluding the current standing timber.

Valuation methods for timber

7.253. The theoretical value of standing timber is equal to the discounted future stumpage price for mature timber after deducting the costs of bringing the timber to maturity. The stumpage price is the price paid by the feller to the owner of the forest for standing timber. The costs include thinning (net of any receipts), other forest management costs and rent on the forest land. For non-cultivated forests, the management costs are very low or even zero.

7.254. Applying the ***present value*** method as described in section D to forests is relatively complicated and requires much data on the age structure and growth rate of the forest, on forest management costs and on the rent on land. Therefore, simplified methods are often applied. They differ mainly in the complexity of the modelling of revenue and production costs, the data that they require and the way the rate of discount is determined. Two such valuation methods are the ***stumpage value*** method and ***consumption value*** method.

Simplified present value methods

7.255. In many applications, the value of the standing timber is based on the receipts from felling of mature timber only while costs are neglected.

7.256. On the basis of a forest inventory, the standing timber is distributed by age classes (for example, 20-year classes). Estimates are made of the harvesting age and volume of standing timber per hectare at the harvesting age. These volumes are multiplied by the stumpage price to estimate future receipts, and discounted to estimate a value per hectare for each age class. These values are multiplied by the total area of each age class and added to give the value of the total stock of standing timber.

7.257. Because yields, prices and harvesting ages differ by species, this method should be applied to each main species separately. Since it neglects intermediate costs and receipts, as well as the rent on land, the method introduces a bias (of unknown size) in relation to the theoretically correct value. It is most reliable when the costs are relatively small in relation to value; this may be true for many cost elements. In particular, the actual rent on land may be very low or even zero in some areas.

7.258. In a more realistic variant, an average management cost is introduced. This may be calculated by dividing actual forestry costs by the forest area based on information from forestry experts or on analysis of the accounts of forest companies.

Stumpage value method

7.259. The method described above can be simplified further by assuming that the rate of discount is equal to the natural growth rate of the forest. This offsets the need for discounting, so the value of the stock is obtained by multiplying the current volumes of standing timber by the stumpage prices (still neglecting costs).[26] This is known as the stumpage value method or net price method.

7.260. In the simplest variant, an average stumpage price is calculated and applied to the whole stock of standing timber. Physical data for the total stock are generally available from forestry statistics and national forest inventories and only an average stumpage price has to be calculated.

7.261. If stumpage prices are not directly available, they may be calculated by deducting the logging, transporting and stacking costs from the "roadside pickup" prices (also called wood-in-the-rough or raw-wood prices). The roadside pick-up price is the price of timber already felled, transported to the roadside and stacked; volumes and values will often be available in industrial statistics. The average stumpage price is then calculated by dividing the stumpage value by the volume of the removals expressed in cubic metres of standing timber (this may require a conversion of the volume of wood in the rough into its standing timber equivalent). More detailed variants apply several average stumpage prices per species to the volume of standing timber per species.

7.262. The average stumpage price is dependent on the age structure of the removals, because stumpage prices are higher per cubic metre for mature trees than for younger trees. This means that the value of standing timber can change because of changes in the age structure of removals. The age structure may change over time because of overexploitation, or when much of the forest results from afforestation programmes (and is young on average).

7.263. When the stumpage value method is used, some potential problems should be kept in mind. For physical data, the volumes should be accurately measured with the correct units. In general, coefficients are used for the conversion involving a cubic metre of standing timber (measured following the prescriptions of, say, United Nations, Economic Commission for Europe, and Food and Agriculture Organization of the United Nations (2000)) and a cubic metre of wood in the rough. These coefficients depend upon the type of wood in the rough (logs, pulp wood, fuelwood) and the way it is measured (with or without bark).

7.264. Physical and monetary data should be consistent. A main problem is fuelwood. Although fuelwood for own final use is within the production boundary of the 1993 SNA (valued at basic prices), it is often not included in the output of the logging industry, whereas it may be included in forestry statistics in physical terms. In most cases, the consumption of fuelwood is estimated as a balancing item, comparing two successive forest inventories.

[26] This is reminiscent of the Hotelling method, but here the discounting is offset by physical growth not by price increases.

Consumption value method

7.265. The consumption value method is a variant of the stumpage value method. The difference is that in the consumption value method, different stumpage prices are used not only for different species, but also for different age or diameter classes. These prices are applied to the stock of timber, which is generally known by species and age or diameter classes through forest inventories. The consumption value method measures the value of the timber as if it were all cut now, hence its name.

7.266. When stumpage prices by species and by age or diameter are available, they can be applied directly. If they are not available, the standing timber stock, described by species, diameter or age classes etc., has to be converted into assortments of wood in the rough using specialized forest algorithms. The potential total production of wood in the rough is calculated by assortment and wood-in-the-rough prices are applied. The logging costs are then deducted in order to arrive at a stumpage value. In the most detailed methods, logging costs are calculated by wood assortment or logging conditions (slope, access etc.). In general, however, an average logging cost by cubic metre of wood is used.

Valuing standing timber: conclusions

7.267. A summary of the alternative valuation methods discussed is given in Box 7.4. The basic difference between the stumpage value method and the consumption value method is that the former uses the structure of the fellings for weighting the stumpage prices, whereas the latter uses the structure of the stock. These two structures may differ considerably and may also change over time. The two methods are special forms of the net present value method (with implicit discounting) and it can be argued that they are in line with SNA principles. However, it is difficult to compare their results analytically with the results of the net present value method. Which of the methods gives more accurate results has to be judged on the basis of the characteristics of the forest to be valued, including the conditions of exploitation. The choice depends upon the current structure of the stock and the fellings and their assumed evolution in the future. The net present value method is best when the forest is managed optimally according to the principles of forestry economics and for large-scale afforestation, where the structure of the stock and fellings will change over time. The stumpage value method gives good results when the current felling structure can be assumed to continue in the future. For old growth and overly mature forest, the consumption value method is a good method.

7.268. An advantage of the stumpage value method is that it can be used to value all the items in the physical timber account in a simple way – not only stocks, but also removals, natural growth and other changes as well. This is not the case for the other methods discussed here.

Box 7.4. Summary of valuation methods for timber

The present box provides formulae for the valuation of standing timber according to the methods described in this section. In each case, the value is a product of the area of the forest (A), the quantity of the timber in terms of cubic metres per hectare (Q) and the average stumpage price per cubic metre (p).

Stumpage value method

This is the simplest formulation; no discrimination is made for the age of the timber at the valuation date.

Using the stumpage value method, the value of standing timber, *S*, is given by

$$S = ApQ$$

Consumption value method

The consumption value method requires data for different age classes from 1 to n. The area, quantity and price for timber of age *t* are shown by a subscript *t*.

Using the consumption value method the value of the stock of standing timber, *S*, is given by

$$S = \sum_{t=1}^{n} A_t p_t Q_t$$

Simple net present value method

In the simple version of the net present value method, only receipts from harvesting mature timber are included; other receipts (from thinning) and costs are ignored. It is assumed the receipts are realized only when the timber reaches maturity at age *T*. At this point, the price realized and quantity to be harvested have subscript *T*. To reach the net present value, discounting using a discount rate of r for each of the (*T-t*) years until harvest must be applied.

Using the net present value method the value of standing timber, *S*, is given by

$$S = \sum_{t=1}^{n} \frac{A_t p_T Q_T}{(1+r)^{T-t}}$$

Allowing for management costs

Suppose information on the management costs per hectare is available. This might be in the form of a simple average, *c*, for the whole forest, or more refined information showing the costs for trees of a given age, c_t, might be available.

The total costs under the stumpage value method will be *Ac*. Under the consumption value method, they will be $\Sigma A_t c_t$. Under the net present value method they will be

$$\sum_{t=1}^{n} \frac{A_t c_T}{(1+r)^{T-t}}$$

Each of these, if available, needs to be deducted from the formulae for *S* given above.

If estimates of the revenue from thinnings are available, additions to the value of the standing timber can be made in each of the formulae in the following similar way:

$$S = \sum_{t=1}^{n} \frac{A_t (p_T Q_T + s_T)}{(1+r)^{T-t}}$$

7.269. Table 7.10 shows test results from Germany, Austria and France for the three valuation methods for standing timber mentioned above. The net present value method gives higher values than the stumpage and consumption value methods in all three countries. The differences between the consumption value and the stumpage value in Germany and France reflect differences between the structure of removals and the structure of the stocks.

Table 7.10. Germany, Austria and France: standing timber values

(European Currency Units per cubic metre)

	Germany 1995	Austria 1995	France 1991	France 1994	France 1996
Consumption	19.7	19.8	32.1		35.3
Stumpage	31.1	22.0	20.8–26.8	23.8–29.7	
Net present value	(53.0)[a]	26.5–28.1	39.5		

Source: Eurostat (2000b).

[a] Indication.

3. Fish

7.270. Fish farmed in an aquaculture establishment are produced assets. These assets are privately owned and can be traded in the market. In most cases, market prices are easily obtainable and can be used to estimate the value of live fish owned by the establishment.

7.271. Monetary valuation of wild fish stocks is more complicated. One possibility is to value the fish stock via the value of fishing licences and quotas where realistic market values are available. The other is to base the value on the net present value of the resource rent of the fish stocks. If there is a perfectly functioning market for fishing licences and if these licences cover the whole stock, then these two valuations should give the same result. Because of market imperfections and uncertainties in the statistical assumptions required for net present value calculations, this is unlikely to be exactly the case in practice. This topic is discussed in chapter VII as well.

An appropriation method for valuing fish stocks

7.272. When fishing rights, instanced by the existence of licences and quotas, are freely traded, it might be possible to estimate the value of the natural resource from the market prices of these entitlements. In many cases, where the government hands the access rights to fishermen, trading in these access rights is prohibited and there is therefore no directly observable market valuation. In some cases, fishing rights may be tied to some asset (often a fishing vessel and, in some cases, land) that is freely traded. In these cases, it may be possible to infer market valuation of the access rights by comparing the prices of the associated assets when fishing rights are attached to them with prices of similar assets that do not encompass any such rights.

7.273. Two forms of quotas are common. An individual transferable quota (ITQ) provides entitlement to an absolute level of catch. An individual transferable share quota (ITSQ) provides entitlement to a fixed share of a total that may itself be variable from year to year in accordance with, for example, international agreements. The value of the quota represents the NPV of the owner's expected income using the quota over its period of validity. If the fishery is managed with such quotas and the quotas are valid in perpetuity, the value of all quotas, at the market price, should be equal to the value of the use of the fish stock. If the quotas are valid for a single year only, the total should give an approximation of the resource rent in that year.

7.274. However, in most of those cases where ITQs and ITSQs are used to manage fisheries, the market in these quotas is far from perfect and so the access rights do not fully reflect the value of the resource. Fishing licences and quotas are often introduced when considerable excess capacity exists in the fishing industry. Unless those setting the total level of the quotas do so based on knowledge of the maximum catch consistent with preserving stocks, the earnings from the catch will not correspond to the level of income that maintains the capital intact. A total permissible catch resulting in fishermen's earnings that are higher than this level will mean that some of those earnings should be regarded as depletion of the fish stocks and not as income.

Valuation based on the net present value of future rents

7.275. The operating surplus for ocean fishing of wild fish stocks can be used as a basis for the calculation of the economic rent of the resource. As in the similar case of subsoil deposits, the total amount of gross operating surplus must be partitioned between that part representing the economic rent of the ship, nets and other equipment used and the part representing the resource rent of the fish.

7.276. There are a number of complications particular to the fishing industry that must also be taken into account. The first arises from the fact that artisanal fishing is very common, especially in developing countries. Here the production account yields an item called “mixed income” as the balancing item rather than operating surplus. This item is so-named because it represents not only a return to the produced capital used and the natural fish stocks but also an element of remuneration to the self-employed fisherman. When this is the sort of data available, an adjustment to remove this element of labour remuneration must also be made.

7.277. Because fisheries frequently target more than one species, it is very difficult to obtain data on the cost of fishing for each species. The joint-production character of the production process creates special complications for the estimation of the cost of fishing for each species.

7.278. Besides permitting fishing in excess of the sustainable level of catch, Governments may sometimes subsidize fishing so that fishing continues even when the resource rent is negative.

7.279. Just as the factor of the sustainable level of catch affects calculations of resource rent using an appropriation method, so does it affect the direct estimation of resource rents. If the fish stock is to be preserved in perpetuity, harvest should not exceed the renewal rate of a stable fish population. When this is the case, the economic rent of the fish and the return to the fish are identical, there being no depletion of the stock. Overfishing results in increased gross operating surplus in the short term, but the deduction for the change in the value of the total stock reduces the income element below the level of income in the stable case. Even when the harvest in a year does not exceed the nature renewal of that year, the situation may still not be sustainable because of overfishing in the past and the need to rebuild an age structure of fish capable of self-perpetuation. An improved calculation of the partitioning of the operating surplus between a depletion and an income element should take into account estimates of the maximum sustainable yield of fish by species and area.

7.280. This is decidedly a complication for the estimation of the appropriate income element in the years actually observed, but it can be even more acute when making projections of the resource rent for future years. It is important to note that biological systems are often quite complicated and the knowledge of these systems, and of their productive possibilities, is usually partial.

Conflicting policy goals

7.281. One factor leading to unrealistic levels of fishing quotas is the desire of Governments to preserve fishing communities. Considerations of employment issues, regional issues and sometimes the protection of a certain way of life enter frequently into decisions on fisheries management. There is thus a conflict here among social, economic and environmental goals. Subsidies that are socially beneficial but environmentally harmful are one instance of what can result in such situations. There is some further discussion on this in chapter VIII.

7.282. One source of conflict is between short-term and long-term objectives and the recording of ownership of the stocks. This issue is discussed in chapter X.

7.283. As explained in chapter V, resource management accounts are not yet well developed, but it is clear that costs incurred by, say, government in order to preserve and enhance fish stocks could be taken into account when undertaking a full accounting of the costs and benefits of fishing. This is referred to again in chapter X.

4. Land

Valuation of the stock

7.284. At first sight, valuation of land by means of observed market prices would seem straightforward; in practice, however, a number of complications arise.

7.285. The first problem is that although there is a market in land, relatively little land changes hands in any year and so a comprehensive set of prices to cover all land types in all locations is seldom if ever available. Even when prices are recorded, they may be subject to many of the distortions described earlier in connection with valuing forested land. Further, some land will never be exchanged on the market. This may include designated public areas, land under traditional patterns of common ownership, and remote and inhospitable land.

7.286. The second problem is that land is almost never sold as a separate asset. Often land under buildings will be sold with the buildings in a single transaction; partition of the value into an element for the land only may be approximate at best, and very frequently such a partition may not in fact be made.

7.287. Sales involving land may also cover aspects other than those related to the initial purpose of the land, such as building or agriculture. A building plot with a spectacular view will fetch a higher price than an equivalent area in a very similar location but without the view. Thus, the amenity benefit is merged with the direct use benefit. Similarly, some ecosystem aspects may be incorporated in the value ascribed to land.

Additions to the value of land

7.288. Whenever land is actually sold, there are transaction costs involved, arising, typically, from the involvement of the lawyers registering the change of ownership of the land and of the estate agents who bring the buyer and seller together. There may also be taxes payable in connection with the land purchase. The SNA refers to these expenses as the “costs of ownership transfer”. These costs are not recoverable by the new owner; any further sale will cover the underlying value of the land itself plus a new set of costs of ownership transfer. As a transaction, the costs to the purchaser of the land are treated as fixed capital formation and they are written off over time by means of consumption of fixed capital.

7.289. Major land improvement schemes are also recorded as capital formation and, when appropriate, consumption of fixed capital is applied over a period of time following the date of the improvement. In the SNA balance sheet, though, the value of the costs both of ownership transfer and of land improvement are incorporated with the value of land as a non-produced asset. As a result, an asset account for land compiled according to the SNA rules on recording of the costs of ownership transfer is rather complex. The annex to chapter X of the 1993 SNA discusses some of these aspects in detail.

7.290. From the point of view of environmental accounting, these complications may not result in useful extra information. Globally, an asset account for land in physical terms is very simple. There may be marginal changes in land area during a year due to erosion or land reclamation but, in general terms, the volume of land in terms of physical extent does not change. What is of interest, though, is the use to which land is put and the type of land cover that supports (or does not support) other forms of life and regenerates the atmosphere. These issues are the topic of more extensive discussion in chapter VIII.

Degradation of land and soil

7.291. The only instance where land is used actively rather than passively occurs when it supports biological resources, whether cultivated or non-cultivated. In fact, the characteristics that lead to biological growth are contained in the soil and thus the valuation and changes in valuation of land may be attributed equally to soil in this case.

7.292. Where land is used sustainably, the soil has an infinite life and therefore no adjustment for depletion is required; the whole value of the resource rent arising from biological growth should rightly be regarded as income. However, where land is being degraded owning to economic activity, a depletion adjustment to income is applicable.

7.293. The degradation of land/soil can be defined as the decline in the biological productivity or usefulness of land and soil resources for their current predominant intended use brought about through the use of the land by humans (Gretton and Salma, 1996). Implicit in the concept of land degradation is the notion that agricultural land use removes something from the soil. In the absence of natural regeneration or land management, the productivity of the land is then reduced.

7.294. Land degradation can involve the changing mineralization of soil which occurs through irrigation, altered soil acidity and heavy metal contamination. It can also involve changes in soil structures and erosion that occurs with soil structure decline, surface scalding, water and wind erosion and mass movement of slopes. Degradation of land resources can also involve changes in biological conditions due to factors such as woody shrub infestation, disappearance of perennial bush, clearing of native vegetation, invasion by feral animals and other pest species, and pollution from farm residues and farm wastes. Offset against these are improvements in land quality from soil conservation, afforestation and other changes in agricultural practices.

7.295. In the context of economic assets established here, land degradation represents the decline in the capital value of land over time caused by economic activity (after deducting price rises due to inflation). This decline in value represents the fall in future productive capacity of the land. As such, it stops well short of a full measure of the cost of land degradation to environmental systems more generally, as it does not include impacts such as the deterioration of river systems.

7.296. Degradation of land or soil leads to a decline in production and hence to a decline in the resource rent earned by the land compared with the resource rent that would have accrued if there had been no decline. To calculate the decline of the value of the land, it is necessary to compute the net present value of future land rent that is forgone due to degradation attributed to the year in question. The impact of degradation, that is, the decline in the value of the land, should be shown as depletion of natural resources even though it is due to qualitative changes in the soil and not to quantitative changes in the land itself.

7.297. There exist some estimates of the value of lost agricultural production in Australia. A few estimates have been cited in the literature but the accuracy of the available estimates and the methodology for deriving these are not very well known. Nevertheless, the relative magnitudes of the estimates in the following examples are illuminating.

7.298. Gretton and Salma (1996) reported a number of studies estimating losses due to loss of agricultural production in Australia. The Australian Department of Environment, Sports and Territories had estimated a loss of about 5 per cent of the value of agricultural production in 1994/95. Similarly, the study quoted a figure for the year 1994/95 from the Prime Ministerial statement on the production equivalent of degradation which was about 6 per cent of agricultural production in Australia. The Cooperative Research Centre for Soil and Land Management (1999) estimated the costs (on-farm costs and off-farm indirect impacts on other parts of the economy) to the Australian economy of the adverse impacts of sodic, acidic and saline soils. This loss was approximately double the results reported for the period five years earlier, of which about 90 per cent had been attributable to on-farm cost or crop yield losses. A report commissioned by the National Farmer's Federation and the Australian Conservation Foundation estimated that the annual cost of degradation in rural landscapes was of the same order and could treble by 2020 if no action was taken (Virtual Consulting Group and Griffin nrm Pty, Ltd., 2000).

7.299. When farming practices, such as allowing the land to lie fallow for a period, lead to an improvement in soil quality and the expectations of higher resource rent in future, this should be recorded as land improvement within the SEEA.

5. Valuation of water resources

Valuation of water

7.300. Very large quantities of water flow through an economy, some as natural resources, some as ecosystem inputs, some as products and some as residuals, as described in chapter III and as further elaborated in chapter VIII. It may not be feasible to try to compile a complete water account including opening and closing balance sheets, partly because the level of the water stocks may be unknown. However, even if it is known, valuation may be very difficult.

7.301. Up until the present, water has often been made available free as a public service or for a flat charge because it has been seen to be freely available and not subject to scarcity. The costs, therefore, have tended to be related to the cost of transporting water by pipe to designated outlets rather than to the volume of water consumed. There are indications that this is changing in many parts of the world and the change may accelerate as demand for water increases with increasing populations and increasing prosperity.

7.302. Water valuation is crucial for water management decisions, in particular for those related to the allocation of water to different uses in the presence of increasing demands for freshwater and limited supply. Decision makers in many nations face many questions: How much water should be allocated to agriculture for irrigated food production? How much should go to cities for final consumers and to industries? How much is needed for hydropower generation and in-stream uses? How much groundwater should be pumped now and how much should be saved for future needs? How much groundwater versus surface water should be extracted? How much should the beneficiaries of water pay for water supply?

7.303. There are two main ways in which water can be valued: the uncontroversial method that uses the direct market price; and the appropriation method. Other, less satisfactory methods are sometimes used.

Market prices

7.304. The privatization of formerly public utilities has led to more direct charging. Sometimes, this is still on the basis of a flat fee per dwelling; more often, there has been a shift to charging by volume consumed. Even when charges are levied per litre consumed, the rates charged may vary considerably from one kind of user to another. For example, one form of subsidizing agriculture may entail offering bulk water supplies at very advantageous rates. This may lead to excessive overuse with consequent shortages for other consumers. For the purposes of sound management of the resource, monetary accounts should be drawn up to show the different classes of consumer linked to the different rates charged.

Appropriation method

7.305. Another form of pricing whose application is growing entails the issuing of water rights. These may offer a short-term rental of a water source or perpetual water rights. Short-term rentals grant rights for a limited period of time, say, for one irrigation cycle or a season. The prices observed in this situation are short run and may often reflect other factors in addition to the marginal value of water. The prices paid for the rights can be taken as the value of the water available in the period covered by the rights. A value for the total stock of water can be estimated using net present value techniques applied to future rights issues. Prices paid for perpetual water rights represent an immediate estimate of the stock of water to which the rights give access without the need for net present value calculations. There is, however, an element of speculation involved in determining those prices and care should be exercised in using them with an underdeveloped market in such rights.

Other methods

7.306. In principle, it would be possible to calculate a resource rent for water used for irrigation by looking at the rent for similar unirrigated land and attributing the increase for the irrigated land to the water used. In practice, however, it is unlikely that the same crop will be grown extensively on near-identical land with and without irrigation so this is not likely to be a very practical means of valuation.

7.307. The valuation technique of last resort, which is least satisfactory from a theoretical point of view but perhaps most common in practice, is to set the value of water equal to the cost of making it available. This is to confuse the price of the water with the cost of the means of delivery, as noted above, and is likely to prove increasingly unsatisfactory as pressure on water supplies increase.

6. Ecosystems

7.308. Few attempts have been made to establish asset accounts for ecosystems. Many of the reasons for this are practical and are linked to such challenges as determining a suitable unit of account, deciding how to deal with the “collective” nature of a complete ecosystem, delineating the borderline of the ecosystem of interest, and defining the extent of possible duplication when an entity interacts in more than one ecosystem.

7.309. However, there is no reason in principle why accounts should not be drawn up for at least some aspects of ecosystems. For example, physical and monetary estimates could be provided for each of the services offered by forests. This would entail calculating, for example, the amount of carbon dioxide absorbed by a country’s forests in a given period and estimating the value of this service to the population. The same would have to be done for all other services offered by the forest. Of course, it may not be possible to derive the same sort of physical and monetary estimates for each service. For some, it may be necessary to use some of the techniques discussed in chapter IX for imputing a value of services. For example, the amenity service of the environment may be reasonably measured in monetary terms via a willingness-to-pay survey or in terms of admission fees to a national park, whereas the parameters of the physical amenities may relate to number and types of species present, distance to main conurbations, sporting facilities and so on. In contrast, the monetary value of habitat might be very difficult to estimate, while the physical extent of habitat (at least for a particular species) might be rather easily measured.

7.310. When it is neither possible nor desirable to provide individual estimates for each service of an ecosystem, it may therefore be possible to present only a single set of statistics that incorporates all the services offered by the system. In the forest example, this might consist of a physical estimate of the extent of the forest and a corresponding monetary estimate of the value of the forest to the population (aside from the value of the timber it contains, which is classified as a natural resource asset). The deficiencies of such a solution, however, should be clearly recognised. Natural resources can be measured in physical terms and valued, albeit with some practical problems. On the basis of this, analyses can be carried out to show whether or not these assets are being used by the economy in a sustainable way. Ecosystems are by their nature less amenable to "economic" measurement and valuation and thus it is extremely difficult (or may even be misleading) to make judgements on the ecological sustainability of a course of action based on economic accounts. In order to have a more rounded and complete view of ecological sustainability, indicators reflecting ecological conditions must be used to complement the SEEA accounts.

7. Other changes in assets

7.311. The SEEA asset account contains three groups of items between the opening and closing balance sheets: those for additions to stock levels, those for deductions from stock levels and those for other changes in stock levels. This last heading contains four items: the effects of catastrophic losses, unforeseen obsolescence and environmental degradation of produced assets, changes in ownership, and valuation changes. The basis of valuing the entries under catastrophic losses and uncompensated seizures, and changes in ownership are exactly as described above for additions to and deductions from the stock levels of the asset in question. The item relating to produced assets is not relevant for environmental assets. The principles underlying the entries for valuation changes are different and are discussed below.

Valuation changes

7.312. The entries for valuation changes relate to changes in value that take place solely because of changing prices. These price changes may affect all items in the economy similarly and correspond to the change in the general level of inflation or they may arise from differential movements in prices. Changes in prices affect all assets, but the effects are likely to be greatest for mineral and energy supplies where the price of the commodity is governed by world prices. Similarly large fluctuations may also affect agricultural commodities held in store from one year to another, though these should be treated in the accounts as products and not as non-produced assets.

7.313. The change in the value of the stock level due to the change in the resource rent from one year to the next gives some indication of the extent of holding gains or losses experienced because of changing prices. The figures for rr_t and rr_{t-1}, like all the symbols representing flows, relate to the value during a year and are thus normally assumed to be expressed at the average prices of the year concerned. The values of the stocks to be entered into balance sheets, should, however, be expressed in the prices of the date to which each balance sheet relates. Thus in principle, it is necessary in respect of each flow variable (a) to adjust back from average year prices to start-year prices and (b) to adjust forward to end-year prices. In a period of rising prices, the full value of holding gains in a year consists of the increase in price of resource rent between the start and the end of the year on all stocks held throughout the period, plus the increase from the start of the year until the time when the resource is extracted or disposed of, plus the increase in price between the time of discovery, reappraisal or acquisition and the end of the year. If prices fall, holding losses are calculated in a similar manner but working back to the previous higher price instead of forward to the next higher price.

7.314. For natural resources and produced fixed capital, the change in value of the stock is likely to be largest in respect of the stocks held throughout the period, though for items whose prices are volatile during the course of a year, the other effects may be significant also. Because resource rent is calculated as a residual, it may show a change even when the world commodity price does not change owing to changes in other costs associated with exploitation and extraction of the resource.

7.315. As noted, the valuation to be placed on an entry in the balance sheet should be based on the prices prevailing at the date for which the balance sheet is compiled. If the market is working as expected, allowance for relative future price changes will be reflected in the current market prices and thus, in principle, no extra allowance is to be made for expectations in respect of the change in relative price of the commodity over its future life length. In any case, no allowance should be made for expected increases in the general price level. For this reason, the discount rate to be used in an NPV calculation should be expressed in terms of an unvarying price level also. Sometimes, though, calculations will be based on future resource rent with built-in projections of price changes (usually increases). When this is the case, then the discount rate should also reflect changes in price. Ambiguities arise, though, when the general price level built into a nominal discount rate increases at a different rate from that of the price projected for the resource.

7.316. For some analyses, alternative estimates of stocks of assets may be useful. If world commodity prices are fluctuating, there may be estimates made of the stocks of resources based on long-term trend prices rather than the prices at the date of the balance sheet. Stock levels expressed in the prices as of the balance-sheet date may be less relevant for corporate decision makers (extractors) involved in long-term projects. Investment decisions for assets where the returns are either delayed or spread over a lengthy period are a medium-to-long-term proposition. Further, in the case of subsoil asset extraction, mining leases often specify fixed production rates and extractors negotiate fixed prices for their commodities some years in advance. For this reason, the use of moving averages of prices, production, and discount rates covering five years or more is likely to yield more stable and reliable estimates.

F. Integrating asset accounts with the flow accounts

1. Asset accounts versus accumulation accounts

Reclassifying capital formation

7.317. Section E of chapter VI showed how the full set of SNA flow accounts can be portrayed in a matrix format and then how alternative variations can be created to highlight areas of special interest or to introduce alternative and additional classifications. The purpose of the present section is to show how the presented shown in Table 6.5 can be expanded to incorporate asset accounts for all SEEA assets. Such an expanded matrix is presented in Table 7.11.

Table 7.11. Accounting matrix including asset accounts

			National economy										National asset accounts			
			Goods and services (products)	Use of products	Generation of primary income	Use of assets	Distribution of primary income account	Secondary distribution of income account	Use of income account	Capital account	Financial account	Rest of the world economy	Produced assets and land	Natural resources	Ecosystems	Rest of the world environment
			1	2a	2b	2c	3	4	5	6b	7	8	6a	9a	9b	10
													Opening stock levels	Opening stock levles	Opening stock levels	
National economy	Goods and services (products)	1		Intermediate consumption					Final consumption			Exports	Capital formation by asset		Residuals from consumption	Residuals from consumption
National economy	Use of products	2a	Output												Residuals from production	Residuals from production
National economy	Generation of primary income	2b		Gross value added												
National economy	Use of assets	2c			Consumption of fixed capital								Consumption of fixed capital		Residuals from capital formation	Residuals from capital formation
National economy	Distribution of primary income account	3			Net value added		Property income					Primary income flows from the ROW				
National economy	Secondary distribution of income account	4					Net balance of primary income	Current transfers				Current transfers from the ROW				
National economy	Use of income account	5						Net disposable income								
National economy	Produced assets and land	6a				*				Net capital formation by sector			Acquisitions less disposals of non-produced assets			
National economy	Capital account	6b							Net saving	Capital transfers		Capital transfers from the ROW				
National economy	Financial account	7								Net lending or borrowing	Acquisitions less disposals of financial assets					
	Rest of the world economy	8	Imports				Primary income flows to the ROW	Current transfers to the ROW		Capital transfers to the ROW	Net lending to or borrowing from the ROW				Residuals generated by non-residents	
	Natural resources	9a		Natural resource input to production					Natural resource inputs to consumption			Natural resource inputs to ROW economy		Natural resources drawn from the environment		
	Ecosystems	9b		Ecosystem inputs to production					Ecosystem inputs to consumption			Ecosystem inputs to ROW economy			Ecosystem inputs drawm from the environment	
	Residuals			Residuals re-absorbed by production						Residuals going to landfill					*Less* cross-boundary residual outflows	
	Rest of the world environment	10		Environmental inputs to production					Environmental inputs to consumption						Cross-boundary residual inflows	
	Other changes in assets	11											Reclassification to the economy from the environment Other changes	Additions to and deductions from stock levels Reclassification from the environment to the economy Other changes	Other changes	
													Closing stock levels	Closing stock levels	Closing stock levels	

7.318. As noted in the introduction to this chapter, the asset account is seldom used in a purely SNA context. This is because an asset account refers to a particular type of asset, regardless of the ownership of the asset. Within the SNA accounts, the articulation of the accumulation accounts is organized according to ownership rather than by asset. In the case of some environmental assets, such as subsoil deposits or fish stocks, there may be only a single owner and so there is a one-to-one match between the type of asset and the owner. For others, the ownership may be quite diverse. Land is one such case. It is also the case that ownership of produced assets is spread across sectors and industries. Aggregating these assets by type rather than by ownership permits a comparison of the returns to different sorts of assets, independent of the structure of ownership.

7.319. The first task is to introduce a supplementary pair of rows and columns into the matrix relating to capital. Row and column 6 of Table 6.5 are partitioned to show first the classification by type of asset and then the classification by sector, as in the SNA capital account. Row and column 6a in Table 7.11 allow for a cross-classification between products acquired as capital formation and type of asset, and row and column 6b a further cross-classification between type of asset and ownership. The entry appearing in Table 6.8 that would appear in the shaded cell at the intersection of row 1 and column 6b now appears in row 1, column 6a.

7.320. Although the fact is fundamental that rows and columns 6a and 6b show a reclassification of the same concepts, it is convenient to set column 6a next to columns 9 and 10 where the other asset classifications are shown. Column 6b is left within the boundary of the flows showing how capital formation is financed by the owners of the assets.

7.321. Capital formation is now shown as acquisition of products according to the type of asset in the row for goods and services and the column for types of asset (row 1, column 6a). The cross-classification between products and type of asset is fairly simple since only a limited number of goods and services are acquired as assets and the mapping between the classifications is straightforward.

Bringing in transactions in land and existing produced assets

7.322. Land is a non-produced asset but one that has always been included within the SNA asset boundary. Enhancements to the value of land brought about by land improvement or just the costs of ownership transfer are included under capital formation as explained in section E. Purchases and sales of land cancel out across the whole economy since only residents may acquire land; but when a sectoral disaggregation of total capital acquisitions and disposals is shown, these purchases need to be shown separately. In fact, existing produced assets may be bought and sold also. From the point of view of total capital formation, they can be largely ignored since only transactions with the rest of the world affect the total economy level but, again, in a sectoral decomposition they should be shown.

7.323. As well as reclassifying the acquisition of new assets by type to sector, therefore, it is convenient to incorporate transactions in existing assets and non-produced assets such as land at this point. This is the starting point for the entry in the row for type of asset (6a) and the column for the capital account (column 6b).

Consumption of fixed capital

7.324. An entry for the consumption of fixed capital was introduced in Table 6.8. It was noted above that the consumption of fixed capital is used to compute net domestic product from gross domestic product as well as net operating surplus from gross operating surplus. In fact, this distinction between gross and net applies to all the balancing items in the SNA. When analysing capital in detail, it is useful to elaborate the treatment of consumption of fixed capital further. In Table 7.11 the production account is subdivided into three elements. The first corresponds to the provision of and use of products; the second shows the generation of primary income; and the third, the use of assets. Consumption of fixed capital then appears in the row for the use of assets (row 2c) and the column for primary income (column 2b) leaving net value added as the balancing item that links the generation of income account and the distribution of primary income account. These entries appear shaded in the upper left of Table 7.11.

7.325. There are two possible ways of showing how the consumption of fixed capital affects other entries. One would be to enter it in the row for asset types (row 6a) and the column for use of assets (column 2c). This cell is shown shaded and marked by an asterisk in Table 7.11. An alternative is to enter it in the symmetrically opposite cell (row 2c, column 6a) with a negative sign instead of a positive one, and this is in fact what has been done in the table. This form of recording has a number of desirable consequences. The first is that consumption of fixed capital can be deducted from gross capital formation as part of the asset account in column 6a. The second is that the entry in row 6a for capital formation can now be shown in net terms. If, instead, consumption of fixed capital had been placed in the cell with the asterisk, neither of these consequences would have followed and further manipulation of the table would have been necessary to achieve these ends.

2. Completing the asset accounts

7.326. The entries for other changes in assets are added in row 11 in Table 7.11. The opening and closing stock levels are inserted above row 1 and below row 11, respectively. Column 6a as augmented in this way gives an asset account for produced assets and the non-produced assets captured in the SNA.

7.327. By partitioning the row and column for the national environment to show natural resources and ecosystems separately, we can assemble assets accounts for these two groups of assets in a similar manner. The only other entries that need to be added are those situated where the new rows and columns intersect. Here we use the same device as that used for the consumption of fixed capital. The entry at the (9a, 9a) diagonal is the negative amount offsetting the other entries in row 9a. It shows the total amount of natural resources drawn into the economy from the national environment. It is a negative entry in the asset account, as desired. For the natural resource column only, there is a possible entry in row 11 to show additions to and deductions from stocks of natural resources such as those due to discoveries and depletion of subsoil deposits.

7.328. Entries for opening and closing stock levels of ecosystems are shown to portray the conceptual possibility of compiling an asset account for them, even if this is difficult in practice. For some assets, such as water, for example, it may make little sense to try to develop a figure for total stock levels. Nonetheless, the other entries in the column are relevant and their presentation can be similar to that of those assets whose stock levels are measurable.

3. Examples based on the SEEAland data set

7.329. The present section provides examples of how the techniques described earlier in the chapter can be applied to the data for natural resources in the SEEAland data set.

Example of asset accounts for oil and gas

7.330. Compiling the asset account in physical terms is fairly straightforward. Table 7.12 shows the account based on the SEEAland data set. The inputs of oil and gas are consistent with those shown in all the hybrid accounting matrices.

Table 7.12. Physical asset account for oil and gas

Millions of tons

	Gas		Oil	
	Previous year	Current year	Previous year	Current year
Opening stock	1 215	1 200	570	550
Additions and discoveries	10	7	10	22
Extraction	-25	-27	-30	-38
Closing stock	1 200	1 180	550	534

Source: SEEAland data set.

7.331. The starting point for compiling the asset account in monetary terms is the estimation of values for the resource rent for oil and gas. This is shown in Table 7.13 using both approaches described in section D. Both start from a figure for gross operating surplus. The first approach deducts first the value of consumption of fixed capital and then the return to fixed capital to give the value of the resource rent; the second simply deducts the value of the capital services rendered by fixed capital.

Table 7.13. Calculation of resource rent for oil and gas

Billions of currency units

Gross operating surplus	104.1
Consumption of fixed capital	
- Mineral exploration	4.1
- Other fixed capital	20.8
Net operating surplus	79.2
Return to fixed capital	
- Mineral exploration	3.3
- Other fixed capital	17.6
Resource rent	58.3
Gross operating surplus	104.1
Capital services	
- Mineral exploration	7.4
- Other fixed capital	38.4
Resource rent	58.3

Source: SEEAland data set.

7.332. Based on this information, net present value techniques are used to determine the value of the stock levels. The life length of the deposits is assumed to be 44 years for gas and 14 years for oil. These assumptions are made without allowing for the impact of new discoveries on the life length. A discount rate of 4 per cent and a rate of return of 8 per cent have been used. As well as calculating the value of the opening and closing stocks, this information has been used to calculate the decomposition of the change between the two stock levels. This is shown in Table 7.14.

Table 7.14. Monetary asset account for oil and gas

Billions of currency units

	Gas	Oil
Opening stock (= closing stock of previous year)	175.6	523.2
Changes due to		
Extraction (resource rent)	-9.3	-49.0
Return to natural capital (revaluation due to time passing)	7.7	21.2
Discoveries and reappraisals	0.4	16.2
Changes in extraction path	9.3	34.7
Change in the unit resource rents (nominal holding gains/losses)	6.5	-27.5
Closing stock	190.2	518.8

Source: SEEAland data set.

Example of asset accounts for the timber resources of forests

7.333. In these examples, both cultivated and non-cultivated forests are assumed to be managed sustainably with no depletion taking place. Table 7.15 shows the physical asset account for non-cultivated forests.

Table 7.15. Physical asset account for timber in non-cultivated forests

Millions of tons

Gross increase in timber	45 060
Residuals from felling	580
Other natural deductions	1 480
Increase in standing timber	43 000
Timber felled	9 000
Net increase in standing timber	34 000

Source: SEEAland data set.

7.334. It is assumed that some forestry activity is performed by self-employed workers, so the national accounts first produce a figure for mixed income rather than for gross operating surplus. From this, an estimate of the compensation of labour must be made in order that a figure equivalent to gross operating surplus may be derived. Thereafter, the calculation is similar to that described earlier. The calculation is shown in Table 7.16.

Table 7.16. Calculation of resource rent for timber in non-cultivated forests

Millions of currency units

Mixed income	649
Compensation of labour	100
Gross operating surplus	549
Consumption of fixed capital	174
Net operating surplus	375
Return to fixed capital	133
Resource rent	242
Gross operating surplus	549
Capital service of fixed capital	307
Resource rent	242

Source: SEEAland data set.

7.335. The monetary asset accounts for forestry in Table 7.17 encompass an account for cultivated forests, an account for non-cultivated forests and an account for the fixed capital used in both forms of forestry. In this case, the discount rate is assumed to be 3 per cent and the return to capital, 4 per cent.

Table 7.17. Monetary asset accounts for forestry

Millions of currency units

	Cultivated forests	Uncultivated forests	Fixed capital
Opening stocks	9 000	8 068	7 245
Gross fixed capital formation			269
Consumption of fixed capital			378
Change in inventories, work in progress	- 120		
Change in inventories, other			0
Harvest of natural biological resources (timber)		242	
Natural growth of non-produced biological assets		242	
Other changes in assets			
Reclassification			
Price changes			
Catastrophic losses			
Closing stocks	8 880	8 068	7 136

Source: SEEAland data set.

Example of asset accounts for fish

7.336. In Table 7.18 and Table 7.19, three hypotheses about the levels of wild fish stocks are examined. All three of them are based on the assumption that the catch in each year amounts to 2 million tons. Associated with this usable catch is an amount of 50,000 tons wasted. In addition, 1 million tons a year are attributable to natural death.

7.337. Three separate assumptions are made about the level of stocks. In case 1, it is assumed that the level of stocks is unknown but increasing so that the level of catch is sustainable without depletion. In case 2, the initial stock is 14 million tons and grows at a rate of 10 per cent per year. Because depletion is consistently higher than natural growth, the stock is exhausted within 10 years. In the third case, the stock level is unknown but a figure for net growth is known.

7.338. Table 7.18 shows the calculation of resource rent on the two alternative bases as shown for oil and gas. In the case of capture fishery, it is assumed that a part of this activity is performed by artisanal fishermen, so that the national accounts first produce a figure for mixed income rather than gross operating surplus. From this, an estimate of the compensation of labour must be made in order that a figure equivalent to gross operating surplus may be derived. Thereafter, the calculation is similar to that set out earlier.

Table 7.18. Calculation of resource rent for capture fisheries

Millions of currency units

Mixed income	2 318
Compensation of labour	750
Gross operating surplus	1 568
Consumption of fixed capital	970
Net operating surplus	598
Return to fixed capital	516
Resource rent	82
Gross operating surplus	1 568
Capital service: fixed capital	1 486
Resource rent	82

Source: SEEAland data set.

7.339. Table 7.19 presents an asset account for fisheries. It gives information on the farmed fish in aquaculture as well as the fixed capital used in that industry. It also provides figures for the fixed capital used in capture fishery as well as estimates of fish stocks, and changes in them, under the three cases described above. Even though the physical size of the stock is unknown in case 1, it is possible to place a monetary value on the stock on the basis of the resource rent derived each year and on the assumption that the stock is non-declining. In all cases, the discount rate and rate of return are both assumed to be 4 per cent.

Table 7.19. Monetary asset accounts for fisheries

Millions of currency units

	Aquaculture		Capture fishery			
	Fixed capital	Farmed fish	Fixed capital	Wild fish Case 1	Wild fish case 2	Wild fish case 3
Opening stocks	3 200	650	12 900	2 050	610	Unknown
Gross fixed capital formation	304		1 087			
Consumption of fixed capital	240		970			
Change in inventories, work in progress (farmed fish)		311				
Change in inventories, other						
Harvest of non-cultivated biological resources (catch)				82	82	82
Returns to natural resources					24	
Natural growth of non-cultivated biological assets				82		21
Other changes in assets						
Reclassification						
Price changes						
Catastrophic losses						
Closing stocks, biological assets	3 264	961	13 017	2 050	552	Unknown

Source: SEEAland data set.

Chapter VIII. Specific resource accounts

A. Overview

8.1 The present chapter describes resource accounts for each of the main categories of environmental assets. It discusses in turn mineral and energy resources, water resources, biological resources as exemplified by forest and aquatic resources, and land and ecosystems. The order is that of the SEEA classification of environmental assets and should not be interpreted as indicating any sense of priority among the areas. There are cases where considerations of different assets overlap. For example, discussion of all aspects of forest resources inevitably involves some discussion on land.

1. Objectives

8.2 The chapter sets out to show how many of the techniques described in previous chapters can be brought together to give a rounded picture of different aspects of a single asset or related group of assets. The types of accounts presented have different emphases for different resources. This approach is intended, on the one hand, to reflect the different characteristics of the resources considered; and, on the other, to demonstrate the flexibility offered by the SEEA with respect to providing an interface between environmental accounting and environmental statistics more generally. The examples presented should be regarded as illustrative; though some accounts fit a given sort of resource more readily than others, there is no intention to tie one particular form of analysis rigidly to only one type of resource.

8.3 This chapter does not introduce any new techniques per se. The idea of supply and use balances in physical terms is taken from chapter III and the juxtaposition with monetary data from chapter IV. Expenditure related to environmental protection is treated as described in chapter V and the issue of environmental permits and licences as addressed in chapter VI. Questions relating to monetary valuation of assets are addressed in chapter VII along with the construction of asset accounts. Any implications for macroeconomic aggregates of flows of the assets are explored in chapter X. More policy applications appear in chapter XI. The effect of environmental degradation, especially in the case of water, is the subject of chapter IX.

8.4 This chapter has multiple objectives depending upon the resource in question. For some resources, (for example, minerals) the objective is to provide additional detailed treatment on specific questions that have not been dealt with elsewhere in the handbook. For other resources (for example, land and water) that are not dealt with extensively elsewhere in the handbook, the objective is to give a more or less complete exposition of their accounting.

2. Mineral and energy resources

8.5 The discussion on mineral and energy (or subsoil) resources in this chapter complements that given in chapter VII where the question of placing a valuation on them was discussed at length. The focus of attention here is twofold, comprising, first, the measurement of the resources in physical terms and, second, the interaction of the valuation to be placed on the resource with the valuation placed on the economic activities that permit its extraction for absorption into the economy.

8.6 Physical asset accounts for subsoil resources seem relatively straightforward, though care is needed to define how sound is the knowledge of the extent of such resources. Subsoil resources are not renewable on a human timescale and so it seems at first sight that any use of them must be non-sustainable. The extent to which they are being used non-sustainably, however, may be modified in the light of new knowledge on the extent of resources available.

8.7 Subsoil resources are the only natural resource that directly interact with only one living species - mankind; and that interaction occurs entirely in the marketplace. Exploring the complex of monetary activities related to the extraction activity and the dividing line between valuation of a production activity and that of the deposit itself is a matter for discussion in section B. Closely related to this matter is the question who can claim to own the resource and who bears the cost of the rundown in its stock.

3. Water resources

8.8 Section C on water resources brings together SEEA considerations of the flows of water as a natural resource, an economic product and a residual. The hydrological cycle shows how water is drawn from liquid water bodies into the atmosphere as vapour (evapotranspiration) and then returned to earth in the form of precipitation. The concern in the SEEA is mainly with the stages that intervene between precipitation and evapotranspiration.

8.9 Considerable use is made of water by some industries for their own purposes, particularly agriculture, for irrigation and energy for cooling or hydropower. Some water is “displaced” by industry but not otherwise used, for example, water pumped out of mineshafts. Water industries abstract water from the environment, distribute it to others, and often recover it as “dirty” water to be treated for either recycling or return to the environment. Section C elaborates accounts where all these phenomena are presented along with their interconnections.

8.10 To date, water has seldom had a monetary value placed on it, so as yet there are no comprehensive monetary accounts for water; nevertheless, the monetary implications of water management are examined in section C along with the issue of water rights.

4. Forests, wooded land and forest products

8.11 Section D presents accounts for wooded land, timber and forest products. Timber reserves are one category of biological resources. While it is useful and practicable to construct accounts for timber, it is more informative to look at the total value of forested land, paying attention to the timber, the land on which it grows, and other forms of ecosystems supported by the forests. All of these are considered in section D.

8.12 Most timber comes from forested land but some wooded land lies outside forested areas. Specific accounts are usually compiled in respect of forests but include the consequences for forested land and forest products also. Timber from other wooded land may or may not be included, depending on the circumstances. Forests exist both as produced assets (cultivated or plantation forests) and as non-produced assets (non-cultivated or natural forests). These categories may resemble one another very closely, hence it is not always easy to distinguish one from the other. It is important to develop accounts that make the distinction apparent and may allow for cases where an alternative view is possible on whether the extent of human intervention is sufficient to be classified as “cultivation” or not.

8.13 Physical accounts for forests make this distinction and also usually spell out the types of tree species involved: whether they are broad-leaved trees yielding hardwood or conifers yielding softwood. Other aspects of forests are also regularly documented in physical accounts, for example, the age structure of the forest which determines the time until maturity of the standing timber. In addition, information pertaining to other aspects of forests (such as by-products in the form of wild animals and fruit, and the change in biodiversity) is often presented in connection with timber-related accounts for forests. Forests also provide environmental services including carbon sequestration.

8.14 Because of climatic variation from one year to another, year-to-year movements in forest growth may disguise long-term trends. It may therefore be preferable to make calculations over a multi-year period or using moving averages to assess whether there is an imbalance between growth and harvest. Indeed, forest censuses are usually conducted over a multi-year period and typically avoid this problem except in cases involving the impact of major catastrophes.

5. Aquatic resources

8.15 The accounts for aquatic resources are presented in section E. Like forests, fish exist both in cultivated and in non-cultivated forms. By convention, only aquaculture (fish farming) is treated as giving rise to cultivated fish and other aquatic resources. All other aquatic resources are treated as non-cultivated, including those whose freedom of movement in the open sea is inhibited by human controls (fish ranching).

8.16 It is difficult to establish the total stock of fish of various species exactly and various indirect measurement techniques must be used to establish the physical stocks of fish by species. Such measurements may have to extend to species that are not used by humans but vital to the ecological chain to which species of interest belong.

8.17 Valuation of commercially exploited wild fish depends on the value of the landed catch. For these species, therefore, there is little difficulty in theory in obtaining a valuation, although in practice all of the necessary data may be difficult to obtain. For those that are simply part of the aquatic ecosystem, valuation is more problematic and not necessarily particularly useful. As with forests, an assessment of physical sustainability may be rather different from that of economic sustainability.

8.18 An important issue for aquatic resources is the issuing of fishing licences and quotas, which are important economic instruments in the preservation of sustainable levels of fish stocks. They are discussed at some length in section E as is the question of the impact of fishing by non-residents in territorial waters.

6. Land and ecosystem accounts

8.19 Land and ecosystem accounts are presented in section F. Land is an asset that is unlike any other natural resource in that it may change in quality owing to human intervention but effectively cannot be either created or destroyed by man (ignoring the activities of reclaiming land from the sea and the impact of possible rising sea levels due to global warming). Nor can land be imported or exported. There are, however, implications for the use of land arising from the patterns of exports created when other countries demand either products embedded in the land (minerals, say) or biological products dependent on the land.

8.20 Data on land use and land cover typically relate to the nature of the use being made of land, changes in this use and changes in the quality of land that may affect its suitability for various purposes. This is an area where the classifications to be used may well vary quite considerably from one country to another depending on the geographical structure of the country and the context of policy interest.

B. Subsoil resources

1. Introduction

8.21 As noted in the overview to this chapter, subsoil (that is, mineral and energy) resources are inanimate and affect other environmental assets only indirectly insofar as activities associated with mineral extraction disturb the natural environment. Viewed narrowly, the problems of accounting for subsoil assets are confined to knowing (a) how to measure the level of stocks in physical terms and (b) how to place a value on these. More broadly, though, there is interest in determining the impact of owning and using minerals on the economy, that is, the activities of the related producing industries of mineral exploration and mineral extraction. Further, there is the question who benefits from the ownership of the resources. Each of these issues is taken up in the subsections that follow.

8.22 The issues surrounding the definition of what exactly constitutes a subsoil deposit affect decisions made in respect of other assets, in physical as well as in monetary terms. Because there are different valid opinions about how some problematical issues should be resolved, in places a number of options available to the implementer are listed. In this chapter, as in chapter VII, these are presented in boxes for easy reference.

2. Asset accounts in physical terms

8.23 For some subsoil deposits, a fairly exhaustive knowledge of the size of the deposit, or at least the knowledge that it will last for a very long time, exists even before extraction starts. For others, knowledge of the size of the deposit changes as extraction proceeds. This is particularly so in the case of oil and gas.

8.24 It is common practice for an oil company to decide to start extraction as soon as it is known that reserves are sufficient to guarantee profitable extraction for a given number of years. This period of time varies from country to country depending on such issues as the extent to which government undertakes to permit foreign companies to operate and judgements about the degree of political stability needed to underwrite this commitment. Figures for how long reserves of “proven” oil will last vary from about 10 years in many OECD countries up to 40 years in some developing countries.

Categories of oil stocks

8.25 Reserves of oil are grouped into different categories depending on the certainty of knowledge concerning them. Though different categories are used in different parts of the world, three terms in common use are “proven”, “probable” and “possible” reserves. For “proven” reserves, it is known that extraction is both technically feasible and economically viable. As regards “probable” reserves, it is known that they exist, but there is some doubt whether they are technically or economically viable. In the case of “possible” reserves, however, there is considerable doubt regarding the technical and/or financial viability of extraction. In addition, two other classes of reserves are sometimes referred to “potential” reserves and “speculative” reserves. “Potential” reserves are known to exist but it is thought that extraction is not technically or economically feasible. Although “speculative” reserves have not been positively identified, it is reasonable to expect, based on previous geologic experience, that they will be discovered in the future. For the United Kingdom of Great Britain and Northern Ireland, the probabilities of viable extraction attached to the classes of proven, probable, possible and potential reserves are over 90 per cent, between 90 and 50 per cent, between 50 and 10 per cent, and under 10 per cent, respectively. The size of the reserves typically decreases as the certainty of their viability increases. It is quite common for the stocks of oil based on these categories to be shown in a McKelvey box (McKelvey, 1972).

8.26 Table 8.1 presents such a box for the oil reserves of the United Kingdom at the end of 1999. The most certain reserves are in the cell at top left. As one moves to the right across the columns or down the rows, there is a decrease in the economic or technical feasibility of extracting the reserves. The associated uncertainty is indicated by the fact that the figures for the two lowest categories are given as ranges rather than point estimates.

Table 8.1. McKelvey box for continental shelf oil reserves, United Kingdom, 31 December 1999

Millions of tons

	Discovered reserves				Undiscovered reserves
	Proven Over 90 per cent	Probable 50-90 per cent	Possible 10-50 per cent	Potential additional Less than 10 per cent	Hypothetical or speculative
Economic	665	455	545	85 - 370	250 – 2,600
Marginally economic					
Sub-economic					

Source: United Kingdom Office for National Statistics, 2001.

8.27 Other criteria may also be used in classifying reserves. In the case of oil, these may relate to the sulphur content or to the specific gravity. For other minerals, it may be the mineral content of the lode.

8.28 The SNA only records assets with monetary values and formally includes only proven subsoil reserves in its list of assets. The SEEA includes proven, probable and possible reserves in its physical accounts. Some countries may also have estimates of "speculative" (sometimes called "hypothetical") reserves which may also be included.

8.29 In some countries, the classification of subsoil asset stocks into proven and probable is not available but only their classification together within a single "established" class. In these cases, this is the category that is included in the SNA since it is all that is available. In some other countries, it is felt that being restricted to proven reserves is too conservative, hence proven and probable reserves are combined, even in the SNA context and even when the two categories are available separately.

Discoveries and reappraisals

8.30 As extraction proceeds and more is learned about the characteristics of a particular oil well, the estimate of the quantity of reserves it contains will be adjusted in the light of new knowledge. If the field is bigger than expected or if it proves technically easier to extract than was previously thought, or if the world price of oil increases so that a greater quantity of oil can be extracted at a profit, then there will be an upward reappraisal of the previously classified stock level. This may lead to a revision of the estimate of the total level of reserves or simply to a shift of some possible reserves to the probable category and some probable reserves to the proven category. Similarly, downward revisions are also possible, in terms of both absolute size and movement from one classification to a less certain one.

8.31 A completely new discovery is likely to be recorded as either probable or possible since extensive investigation is necessary to confirm the viability required of proven reserves. Since no oil is extracted before it has been proven (with the possible exception of the very small amounts that are extracted as part of the proving process), it is possible to think of oil reserves moving through the categories – from least certain to proven – before extraction.

8.32 While there are some reasons why it may be desirable to separate reappraisals from new discoveries (see below), often the necessary information is not made available by oil companies. In such cases, the word "discoveries" is often used to cover both reappraisals and new discoveries. The case where there are no new discoveries and reappraisals have been downward will lead to a seemingly counter-intuitive negative entry in "discoveries" when the two are combined. In general, if there are negative entries for discoveries, it is probable that they are really a combination of both discoveries and reappraisals. To avoid such apparent anomalies, it is suggested that the term "discoveries and reappraisals" should be used in full when the two items are not available separately.

Extractions

8.33 The other change in the physical levels of oil (and other non-gaseous subsoil) reserves during a year is due to the extractions carried out in the period. For gas, the situation is rather more complicated. Gas is often found with oil and it is the pressure exerted by the gas that causes the oil (and some gas) to gush up the well. Some of the gas may be flared rather than put to direct use. Some may be reinjected, especially after extraction has been continuing for some time, to increase the pressure on the remaining oil and allow more oil to be expelled. In such cases, if the gas associated with the oil is being accounted for, an allowance must be made for the decrease in the amount of gas available for other uses due to flaring and reinjection.

Units

8.34 Physical accounts may be compiled in any satisfactory unit, as long as all the elements of the account can be measured in the same unit. For oil, both cubic metres and tons are frequently used, as well as barrels, which is the unit often used in a connection with international oil prices. Conversion rates from one unit to another are not always constant. Allowance has to be made for the quality of the oil in terms of its specific gravity. For gas, allowance has also to be made for the fact that the volume of gas expands as the temperature rises. One way to overcome these variations in compiling energy balances where data for several energy types are combined is to use a unit referred to as "tons of oil equivalent" (toe) which is standardized to allow for variations such as these. This quantity of energy is, within a few percentage points, equal to the net heat content of 1 ton of crude oil.[27] Joules are also used to combine accounts for different energy sources.

Accounts

8.35 Putting together the considerations above on the classification of oil reserves and the nature of the physical changes that may occur within a year, it would be possible to draw up a theoretical asset account as in Table 8.2. This is very data-demanding and in practice some simplification will probably be required. However, some extra information may sometimes be available (for example, the extent of proven reserves currently being exploited) and in such cases an extension of the table may be feasible and desirable. Also, if adjustments to standard units such as tons taking account of quality issues have not been made, it may be desirable to add extra detail to the table showing the effect of different quality levels. In practice, "other reserves" are often expressed as a range between upper and lower bounds. It is then to be decided whether to use a mid-point, apply a probability to the bounds or simply take the lower bound in calculating total reserves.

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[27] The toe is the unit of account adopted by the International Energy Agency (IEA) and is equivalent to 10^7 kilocalories or 41.868 gigajoules.

Table 8.2. Asset account for oil reserves

	Proven	Probable	Possible	Other	Total reserves
Opening stock					
Reappraisals due to					
- New information					
- New technology					
- Price changes					
New discoveries					
Extractions					
Closing stocks					

Uses of physical asset accounts

8.36 The most immediate and obvious use of physical accounts is to compile an indicator that shows whether the stock levels of a given resource are declining and, if so, how quickly. This may be done in terms of the absolute levels or in terms of year-to-year changes. Though mineral and energy resources can never be used in a wholly sustainable way, because they are not renewable on a human timescale, proven reserves may appear to be sustainable if the rate of discoveries and reappraisals keep pace with extractions. Even when this is not so, if the rate of depletion of a deposit decreases from one year to the next, it may indicate that the resource is being used more sparingly than in the past. For some deposits, this may be linked to the possibility of recovering material from recycling or due to technological developments that increase the efficiency of use of the material. All of these are useful indicators for those interested in the degree of sustainability of a nation's resources.

3. Asset accounts in monetary terms

8.37 In order to compile a table corresponding to Table 8.2 in monetary terms, it is necessary to be able to place a monetary value on each of the entries therein. The means of doing so are discussed at length in chapter VII (section E.1).

8.38 Market prices for mineral deposits may or – more probably – may not exist. When market prices do not exist, a valuation by means of establishing the net present value (NPV) of future resource rents must be used. There are three steps involved in establishing this net present value. First, the level of the resource rent in the current period must be estimated. It is then projected into the future. Finally, the set of future resource rents must be discounted to a value in the present period.

8.39 Resource rent is determined by one of two routes. The gross operating surplus of the mineral extractor covers the benefits derived from both the produced assets in use and the natural resource. One way to derive the resource rent directly is to estimate the capital services rendered by the produced assets then deduct this amount from the gross operating surplus. The other is to deduct an amount estimated as the return on produced assets from the net operating surplus. Theoretically, these two approaches should give the same result but in practice they may not.

8.40 Projecting the resource rent into the future depends on a number of parameters as reflected in the following questions: How long will the mine remain in operation? How will the life length of the mine be affected if the rate of extraction alters? What effect do new discoveries have on the expected life length of the mine? What happens to the projections if the unit resource rent varies? There are different possible answers to most of these questions (and the effects of each parameter on the total will vary accordingly).

8.41 The third step in the calculation of the NPV is the choice of a discount factor and here, too, there is scope for differences of opinion.

8.42 All these choices and their consequences are discussed at length in chapter VII. Box 7.2 gives a summary of the methods used to value resource stocks in general and box 7.3 looks at the effects on mineral reserves of the parameters listed here in the second step of the valuation process.

4. Mineral exploration and mineral extraction

8.43 However the resource rent is determined, information about the level of produced assets used in the extracting industry must be available. For this reason, the treatment of decommissioning costs and mineral exploration is intrinsic to the valuation of the resource being extracted.

Decommissioning costs

8.44 In simple accounting terms, the difference between treating an expense as intermediate consumption and treating it as fixed capital hinges on the question when the cost is charged against operating surplus. In the case of intermediate consumption, gross value added is reduced directly and on a one-time basis. For capital formation, the expense is spread over a period of years and affects net value added.

8.45 At the end of production, it is difficult to treat the whole of large decommissioning costs as intermediate consumption when there may be little if any remaining output or value added. Similarly, if they were to be treated as fixed capital, there might be no future value added against which to charge consumption of this fixed capital. From this stems the recommendation elaborated in chapter VI that the costs should be anticipated in terms of consumption of fixed capital so that over the whole time period the sum of consumption of fixed capital offsets the sum of the original capital formation and the cost of decommissioning (again, for simplicity's sake, ignoring the effects of changes in both absolute and relative prices).

Mineral exploration

8.46 It is seldom the case that a mineral deposit is found and extraction begins without the considerable preliminary activities of prospecting for the mineral and then preparing to extract it. During the 1970s, there was extensive exploration for oil in the North Sea. Under the provisions of the 1968 SNA, all the associated expense was treated as intermediate consumption. Because this activity took place before extraction began, there was no production of oil against which to set these costs and so the exploration firms were shown as operating at a loss. This was seen to be undesirable and unrealistic. Companies undertaking such activities, unless they are working on contract to another firm, do not expect to cover their costs as they proceed but to cover them in the long run from the proceeds of the discoveries. These proceeds, in fact, must cover the costs of both successful and unsuccessful exploration. In commercial accounts, the exploration costs are usually treated as a form of capital formation; and in recognition of the fact that the benefits of exploration are delayed, the 1993 SNA introduced a new category of intangible fixed capital, called "mineral exploration" (AN.1121), defined as follows:

> "The value of expenditures on exploration for petroleum and natural gas and for non-petroleum deposits. These expenditures include pre-licence costs, licence and acquisition costs, appraisal costs and the costs of actual test drilling and boring, as well as the costs of aerial and other surveys, transportation costs etc., incurred to make it possible to carry out the tests" (chap. XIII, annex).

8.47 The SNA goes on to recommend that the value of the expenditures be recorded at cost and consumption of fixed capital on this amount be calculated over a period "using average service lives similar to those used by mining or oil corporations in their own accounts" (1993 SNA para.10.91).

Cost of mineral exploration

8.48 This guidance of the SNA on valuation could be seen as misleading. The recommendation to value output at cost is most often used in connection with production on own account where there is no comparable market activity and valuation at the sum of actual costs incurred is recommended as a minimum valuation to place on the activity. Not all mineral exploration is carried out on own account. A reading of the SNA recommendation consistent with the general advice on valuation would be that mineral exploration is to be valued at the market price of such exploration where possible and at cost only when such an alternative is not possible. There is then a question whether a typical mark-up should be added to actual costs in the case of own-account exploration.

Value of mineral exploration and value of the mineral resource

8.49 Treating mineral exploration as capital expenditure rather than as intermediate consumption has an implication for the valuation of the mineral resource. Unless an independent means of valuing the resource is available, the valuation must be determined by means of resource rent calculations. The inclusion of mineral exploration as a form of fixed capital contributes to the allowance for consumption of fixed capital which must be deducted from gross operating surplus to obtain resource rent. Resource rent is thus lower when mineral exploration is treated as capital expenditure rather than as intermediate consumption. As seen from the simplistic example above, net operating surplus is higher in the years in which only exploration and no extraction took place. This is offset by lower net operating surplus once extraction starts and the cost of mineral exploration is treated as a charge on the resulting value added.

8.50 We can therefore see that the value of mineral exploration and that of the resource discovered are inextricably linked. The higher the cost of exploration, the lower the value of the deposit, and vice versa. Similarly, the pattern of the consumption of fixed capital on the mineral exploration affects the balance of value between the two assets. The implications for the accounting system, both the SNA and the SEEA, are quite significant, since the mineral exploration is a produced asset and the mineral resource is a non-produced asset.

8.51 Consider two means of exploring for minerals that are identical in all respects, except that the first is undertaken by a contractor and the second is carried out on own account. Following the recommendations above, the contractor earns, and charges for, some operating surplus. The value of mineral exploration is higher and the value of the mineral resource is lower than if the exploration were done on own account. It is not that there would be no operating surplus in respect of the own account exploration but rather that it would not be separated from other operating surplus earned by the extractor. However, it would add to the resource rent and thus to the value of the reserve. If we allow own-account exploration to include a margin for operating surplus, we effectively alter the balance in the accounts between produced and non-produced assets. Clearly, it would be possible to think of a level of operating surplus that would mean the resource rent fell to zero. In such a case, there would be a zero value for the mineral deposit but a (relatively) high value for the mineral exploration.

What is mineral exploration?

8.52 The recognition of this dilemma calls into question the assumption about the nature of the produced asset we call mineral exploration. The definition from the SNA quoted above is less a description of the nature of the asset than a prescription for the means of valuing it. However, it is the assumption that the asset represents knowledge about the mineral deposit that leads to its being classed as an intangible produced asset rather than a tangible one. Much of the rationalization for the approach adopted in the SNA is based on the similarity between mineral exploration and research and development.

8.53 An alternative view is that it is artificial to try to treat knowledge about the resource separately from the resource itself, since clearly both are exploited simultaneously.

8.54 This view is consistent with a consideration of the economic rent of subsoil deposits which runs as follows. Initially, there is a basic value of an unknown deposit. The activity of exploration, of identifying a deposit and documenting its characteristics, enhances the value of the resource, so that the economic rent of the deposit now covers both its initial value and the costs of the exploration activity. The net operating surplus of the exploration activity covers the return to the produced capital used plus the NPV of the deposit prior to exploration. In the context of this view, the treatment of the mineral deposit is similar to that of a cultivated biological asset. It is a natural process that initially gives rise to the asset, but making the asset accessible to the economy entails not just extraction costs but also essential preliminary costs. These costs should be recorded as fixed capital formation, parallel to land improvement, and may be called “enhancements to the value of subsoil resources”. In the balance sheets, this enhancement to the subsoil resource is aggregated with it and shown as a produced asset called, for example, a “developed natural resource” which includes the contribution of productive activities to the value of the resource. In this case, there would be no separate asset of “mineral exploration” recorded. This treatment is advanced in Nature's Numbers, a recent report of the United States National Research Council on environmental accounting (Nordhaus and Kokkelenberg, 1999), but is not favoured as yet by the majority of national accountants.

Is there double counting in respect of mineral exploration and mineral resources?

8.55 It is sometimes asserted that the decision to introduce mineral exploration as an asset additional to the non-produced mineral resources leads to a double counting of assets. As shown above, this is not so if the calculation of the value of the deposit is such that the value of the mineral exploration is excluded from the resource rent forming the basis of the valuation of the deposit. However, the possibility of making an estimate of the deposit other than by means of the resource rent exists. Where markets in mineral deposits exist, direct observation may be possible. If a market exists for discovered fields, the market price should reflect the value of the combined asset of mineral exploration and mineral resource, and would be higher than the NPV of the resource rent for the mineral resource.

8.56 Another means of estimating the value of the deposit is to base this on the payments due from the extractor to the owner where these two are different. Whether a valuation based on such payments will be consistent with a valuation based on resource rent will depend on at least two factors. The first is whether the level of future payments agreed between the owner and extractor changes in response to factors affecting future resource rents, for example, the levels of future discoveries, changes in the commodity price of the mineral relative to the overall level of prices, and changes in technology that affect both the cost of extraction and the demand for the mineral. The second is that the agreement may not have been predicated on the assumption that the owner wished to recoup all of the resource rent. If the agreement is more in the nature of a production-sharing arrangement, so that the owner shares in the potential benefits of the sort of changes just mentioned, the extractor may be allowed to retain a share of the resource rent as his share of the joint exercise.

8.57 Whatever the reason, if there are independent measures of the value of the mineral deposit, then there is no certainty that the sum of the mineral exploration and the resource will together exactly match the total return expected from the extraction process. While it is not a question of exact double counting, there is a real probability that there will be either under- or overcounting of the total level of assets.

Options for recording the values of mineral exploration and mineral deposits

8.58 There are three possible ways of recording costs associated with mineral exploration and the value of the relevant mineral deposit. These are shown in Box 8.1. Options 1 and 2, but not option 3, are consistent with the SNA. Options 2 and 3, but not option 1, are consistent with the principle of valuing assets according to a concept of the capital services that these assets will yield in production.

Box 8.1. Options for recording mineral exploration and mineral deposits

Option 1 is to record values for both the mineral exploration and the mineral deposit from independent sources, neither depending on a calculation of the resource rent of the deposit. There is no guarantee in this case that the sum of the assets will exactly match the net present value of the stream of resource rents; the total maybe either greater or smaller than this, depending on the assumption underlying the valuation of the deposit.

Option 2 is to record the value of mineral exploration based on either market prices or costs (depending on whether it is carried out by a contractor or on own account) and to base the value of the mineral deposit on the net present value of the resource rent calculated to exclude the value of mineral exploration.

Option 3 leads to values identical to those of option 2 but treats the sum of the two values as attributed to a "developed natural asset" which would be recorded as a tangible produced asset. This is in contrast to the SNA, where mineral exploration is classified as an intangible produced asset and the mineral resource as a tangible non-produced asset. There is no impact on the asset account or on the balance sheet of this change (except for headings used) but there are changes implied for the flow accounts as explored in chapter X.

5. Balance sheet entries for the assets associated with mineral exploitation

8.59 The SEEA makes extensive use of the asset account. For any asset, the asset account shows the whole range of impacts on the asset between the opening and closing balance sheet. In the SNA, attention focuses on balance sheet rather than on asset accounts. When the owner of an asset is the unit that uses it in production, there is no difficulty in assimilating the asset accounts for all the assets owned and used by the producer into a single balance sheet. However, further consideration is needed when the unit that uses the asset is not the (sole) owner of the asset. This is very frequently the case in respect of mineral deposits, especially in countries where government has ownership of the asset on behalf of the nation at large.

Ownership in the SNA

8.60 The SNA does not discuss how to determine the ownership of non-produced assets and thus in which balance sheet to place them. By virtue of the lack of any alternative advice, the guidance must be assumed to be that the assets should be recorded in the balance sheets of the legal owners.

8.61 Suppose that government is the legal owner of oil reserves with an agreement that a particular unit may extract them. Then in the SNA, the value of the oil reserves appears in the balance sheet of the government. Attributing the ownership of the mineral exploration may be less easy. If the extractor has carried out the exploration either on own account or via a contractor, then clearly the entries for this asset will be in the balance sheet of the extractor.

8.62 However, as noted above, there may not be an extractor during some early periods of exploration. This may be carried out at the behest of the owner of the putative discoveries even though the owner has no productive activity related to either exploration or extraction. Nevertheless, the appropriate step must be to record the mineral exploration as an asset of the owner. Knowledge of whether a mineral deposit exists and the extent of it is the basis on which the owner can enter into an agreement with an extractor at a later stage. When such an agreement is reached and the extractor starts production, he acquires this knowledge, hence the asset must be transferred to his balance sheet and is written off by the extractor over time as part of the costs of production. In fact, the payments by the extractor to the owner must be sufficient to reimburse the owner for the costs he incurred to acquire the knowledge about the deposit besides representing a return to the deposit itself.

8.63 If the terms of the agreement between the owner and the extractor are such that the extractor can expect to retain some of the resource rent of the asset, it would seem appropriate even in the SNA to record the value of the mineral deposit as divided between the owner and the extractor according to the proportions that each is expected to receive. This might mean that an independent estimate of the owner's valuation of the deposit has been made and the extractor is credited with the difference (if positive) between a value based on the resource rent calculations and the amount due to the owner. This should be seen as a variation of option 2 in Box 8.2.

Ownership in the SEEA

8.64 As regards ownership in the SEEA, there are also a number of options. The first is to follow the SNA recommendations as described above. The second is to say that the agreement with the extractor in effect gives him ownership not only of the knowledge in respect of the deposit but in effect of the asset itself. It is, after all, the extractor who will make decisions about how much to extract and for how long. In return, the extractor enters into a financial arrangement with the owner with a financial claim then appearing in the owner's balance sheet instead of the deposit and the extractor showing the deposit as an asset and the financial liability offsetting it. This line of reasoning is similar to that used in the 1993 SNA for financial leasing (details are given in para. 6.118 of the 1993 SNA).

8.65 Though this solution is attractive in a number of ways, the implication is that the level of the financial claim and liability alters from year to year as does the value of the deposit, as new discoveries are made and changes to the pattern of production are introduced by the extractor. Financial claims are usually clearly specified in advance and not subject to such sorts of alterations.

Box 8.2. Options for recording the ownership of mineral-related assets

Option 1 shows mineral exploration in the balance sheet of the extractor and the value of the deposit in the balance sheet of the legal owner. If the agreement between the owner and the extractor allows for the extractor to retain some of the resource rent coming from the asset, the ownership of the asset should be partitioned consistently.

Option 2 shows both the mineral exploration and deposit as being under the de facto ownership of the extractor. In addition, the extractor has a financial liability towards the owner corresponding to his share of the resource rent. This amount is also shown as a financial claim in the balance sheet of the owner.

C. Water resources

1. Introduction

8.66 Water has a number of particular characteristics that call for rather special treatment in a resource account. Because it is literally a vital resource, since it is fundamental to any form of life, water forms one of the ecosystem inputs recorded in the SEEA. Because it is used by many industrial processes, and through consumption, it also constitutes a natural resource. In some of these cases, water is paid for and represents a product, and perhaps this will be increasingly so in future. Lastly, used or dirty water is discharged back to the environment as a residual. Water is the only environmental asset that can be classified into each of these four sorts of flows.

8.67 Further, measuring water, even in physical terms, is not easy. Water travels under the influence of solar radiation and gravity and it is in continuous movement and transformation. Because it is difficult to measure a stock level of something always in motion and not always in the same physical state, it is common to take some sort of flow measure as a proxy for a stock measure.

8.68 More important than sheer volume may be measures of water quality, but these too are fraught with definitional problems. Water not fit for human consumption may be perfectly satisfactory for some other uses. The point at which water is treated as a residual does not depend entirely on its quality but also on the infrastructure for handling it. As important as quality is, it cannot be used to discriminate between different possibilities for recording flows.

8.69 Even when water is crucial to economic activity, it is seldom priced in the market. Nevertheless, information concerning the monetary aspects of water is important and is presented in section 4.

Water accounting: general principles

8.70 Water resource accounts comprise stock and flow accounts in physical terms as well as quality accounts. Because of the nature of water, a set of physical flows accounts is often the starting point in the compilation of water accounts. Stock accounts are also very important for groundwater, lakes and reservoirs. Accounts are calculated for a given geographical territory, which can be a country, a region or a river basin (catchment area) or any relevant area of interest. Here, the focus is on water accounts at the national level in line with the other parts of the SEEA.

8.71 The accounts offer an integrated view of water supply and uses by industry and by purpose. They include measures of water pollution, protection and management, and describe water quality in physical and monetary terms. The accounts help to understand the interaction between human activity and the environment. They help to identify water availability for various uses, stresses on water, and qualitative and quantitative water scarcity.

8.72 In section 2, the basic concepts of hydrology are introduced and the interaction between the hydrological system and the economy is described. The asset classification of water resources is then discussed in detail and physical flow accounts for supply and use tables for water flows and accounts for water stocks are presented. Numerical examples are included as well as a more theoretical framework.

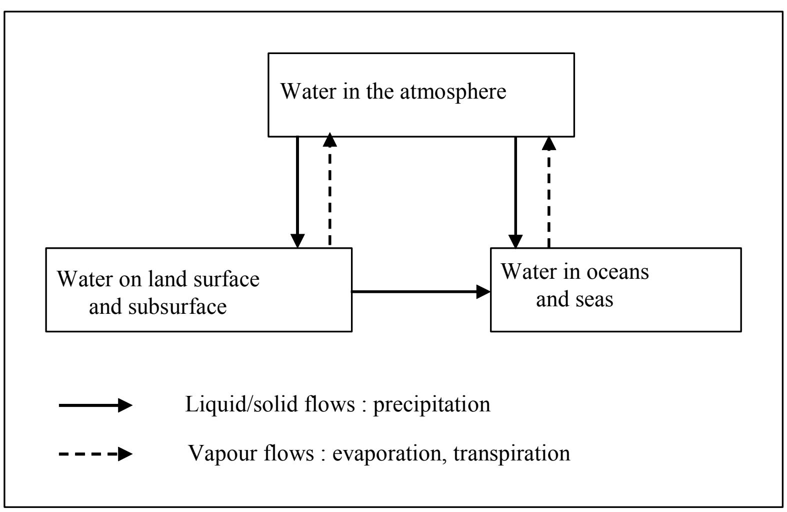
8.73 Several case studies have been undertaken at the national and/or regional level(s). Examples include studies for France, Spain, Denmark, Finland, the Netherlands, Chile, the Republic of Moldova, Australia, Namibia, the Republic of Korea, Canada and the Philippines. Despite the limited experience in water accounting revealed by the case studies and some formal differences that exist in the presentation of the accounts, important similarities can be noted. These similarities result from a systematic organization of data on water resources, water supply and water use that manages to be consistent with the concepts, definitions and classifications of the SNA while respecting the fundamental concepts of hydrology.

8.74 The water accounts presented in the present section include both physical flow accounts and asset accounts. The physical flow accounts are constructed in accordance with the accounting rules outlined in chapter III. They are restricted to measurement of the water flows between the economy and the environment that lie within the scope of physical accounting presented in Figure 3.3. Specifically, they exclude flows of water that occur exclusively within the environment. The asset accounts for water are compiled in accordance with the accounting rules outlined in chapter VII. They are restricted to measurement of the opening and closing stocks of water within the national environment and of the flows associated with the natural and economic processes that account for the difference between the opening and closing stocks.

2. The hydrological system

8.75 When compiling water accounts, it is important to understand the hydrological cycle and to describe what the hydrological system means within a territory of reference. The hydrological or water cycle is defined as "…the succession of stages through which water passes from the atmosphere to the earth and back to the atmosphere: evaporation from the land or sea or inland water, condensation from clouds, precipitation, accumulation in the soil or in bodies of water, and re-evaporation" (United Nations Education, Scientific and Cultural Organization and World Meteorological Organization, 1992). The hydrological system constitutes a system of repositories of water in the territory of reference and the transfers between them. The simplest version of the hydrological system uses three repositories: water in the atmosphere, water in the oceans and seas, and water on the land surface and subsurface. Figure 8.1 shows the main components of the system and the transfers between them. The principal transfers to the atmosphere are represented by evaporation and transpiration, and the principal transfers from the atmosphere by precipitation.

Figure 8.1. Elements of the global hydrological system



8.76 Here we focus only on the part of the global hydrological system that deals with water on land surface and subsurface in the territory of reference, the inland water system. This subsystem can be further disaggregated into various components such as lakes, reservoirs, groundwater, rivers, permanent snowfields, ice, and water in soil.

8.77 The natural input of water to the inland water system is precipitation. Part of this precipitation evaporates back into the atmosphere immediately; part drains into surface water (lakes, rivers, reservoirs) to ultimately end up in the sea; part infiltrates soil and becomes soil moisture and then groundwater. A portion of the groundwater gradually works its way back into surface water (and becomes the main source of dependable river flow) and/or to the sea. Plants and vegetation absorb a part of the soil moisture through their roots and release most of it into the atmosphere in the process of transpiration. Permanent snowfields and ice represent a large store of water in its solid form. They contribute to the flow of surface and subsurface water during snow melt seasons. In addition to these movements of water, there are also natural inflows into and out of the territory of reference from and to other territories and to the sea through rivers and groundwater. This natural system is modified through human activities such as direct abstraction, returns of water and induced evapotranspiration.

Asset classification

8.78 The asset classification of water resources in the SEEA reflects those components of the hydrological system that are available for water abstraction and provide direct inputs into the economy. The stock classification can be described as follows:

EA.13 Water resources

- EA.131 Surface water
  - EA.1311 Artificial reservoirs
  - EA.1312 Lakes
  - EA.1313 Rivers
- EA.132 Groundwater

8.79 ***Surface water*** comprises all water that flows over or is stored on the ground surface (United Nations Education, Scientific and Cultural Organization and World Meteorological Organization, 1992). Depending on data availability and national priorities, the classification could be further disaggregated. Reservoirs can be classified according to the type of use, for example, human, agricultural, electric power generation or mixed uses. Rivers can be classified on the basis of the regularity of the runoff as perennial (where water flows continuously throughout the river) or ephemeral (where water flows only in direct response to precipitation or to the flow of an intermittent spring). Namibia (Lange, 1997), the Republic of Moldova (Tafi and Weber, 2000) and France (Margat, 1992) have used such a breakdown.

8.80 ***Groundwater*** comprises all water that collects in porous layers of underground formations known as aquifers. Aquifers may be unconfined – that is, they have a water table and an unsaturated zone – or confined, when they are between two layers of impervious or almost impervious formations. Unconfined aquifers are recharged during the water cycle by the percolation of rain or melted snow and thus hold renewable groundwater. The water in confined aquifers has accumulated over a geologic time-span and, because of its location, cannot be recharged at all or only over a long time-span. Such water resources are non-renewable or fossil water. (Water in lakes may also be considered non-renewable when the replenishment rate produces a small proportion of the total volume of water).

8.81 The other components of the hydrological system such as soil water, glaciers, permanent snowfields, ice, and marine water are not part of the classification of stocks either because water cannot be abstracted there from (soil water) or because the water abstracted does not have an effect on the size of the stocks (glaciers, marine water etc.). However, it is important to understand the role of these components in the hydrological cycle and to account for them when compiling the accounts. If detailed information on stocks of soil water, permanent snowfields and ice is available, it can be included in a special column in the asset accounts. Several countries including France, the Republic of Moldova, Spain and Chile have compiled accounts for soil water, permanent snowfields and ice. This information is particularly relevant in the case of seasonal accounts when water stored in soil and permanent snowfields in one period is an essential resource for the following one.

8.82 The 1993 SNA asset classification includes only a small portion of the total water resources. Only "Aquifers and other groundwater resources to the extent that their scarcity leads to the enforcement of ownership and/or use rights, market valuation and some measure of economic control" (see 1993 SNA, chap. XIII, annex) are within the SNA asset boundary. In addition, the SNA asset category "land" includes any associated surface water.

8.83 The SEEA extends this boundary to include all water resources that provide both direct use and non-use benefits. This implies that the SEEA asset category "water resources" (EA.13) includes all the water resources that can be extracted in the current period (direct use benefits) or that might be of use in the future (option benefits). In practice, data are more likely to be available in cases where water is scarce and where the services to production and consumption provided by water bodies are threatened or actually diminished.

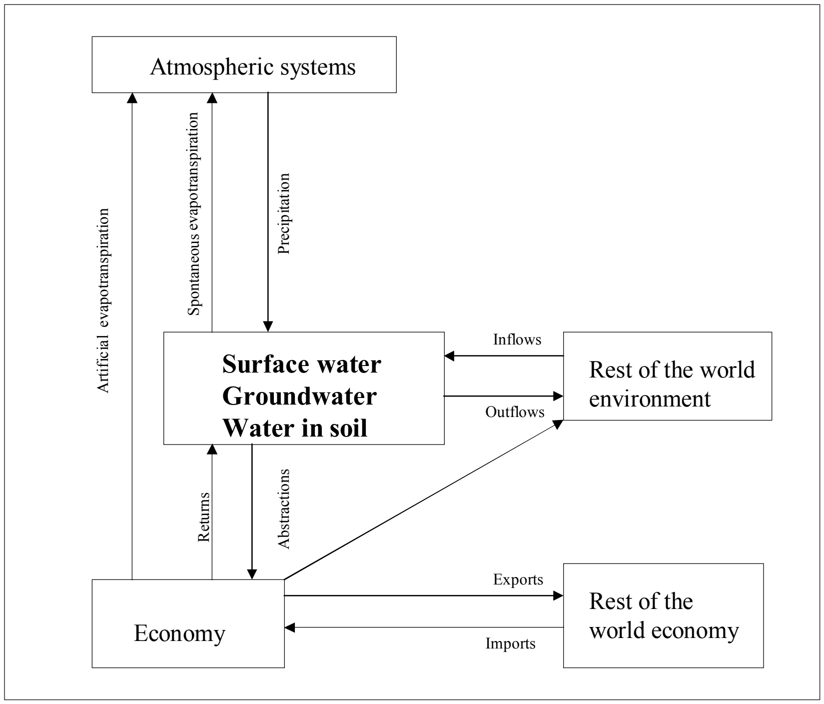
8.84 The SEEA also considers water resources in terms of the area covered by surface water. The area of surface water is included in the "land and surface water" category (EA.2) of the asset classification. Aquatic ecosystems are included in the "ecosystems" category (EA.3) of the classification. Measurements relating to the area of surface water are included under land cover in the section on land accounts below.

Physical flow accounts for water

8.85 Figure 8.2 shows the interaction between the hydrological system and the economy. This expands on the system described in chapter III with particular reference to water and an elaboration of the national environment to show water in the atmosphere separately from surface and subsurface water. The principal flows between these two sections of the environment are precipitation and evapotranspiration as shown in Figure 8.1.

8.86 The exchanges of water between the environment and the economy include direct abstraction, irrigation and returns of water to groundwater, surface water, the sea and brackish water. The passive uses of water by the economy that do not involve direct abstraction, such as recreation or transportation, are not considered here. The storage and release of water in dams are not considered to take place within the economy but within the hydrological system. This is because it is difficult to make a distinction between the direct economic use of the water and what is required for regulating the discharge of the rivers for, say, flood prevention or to support runoff in summer.

Figure 8.2. Schematic representation of the interaction between the hydrological system and the economy



Source: Based on Tafi and Weber (2000).

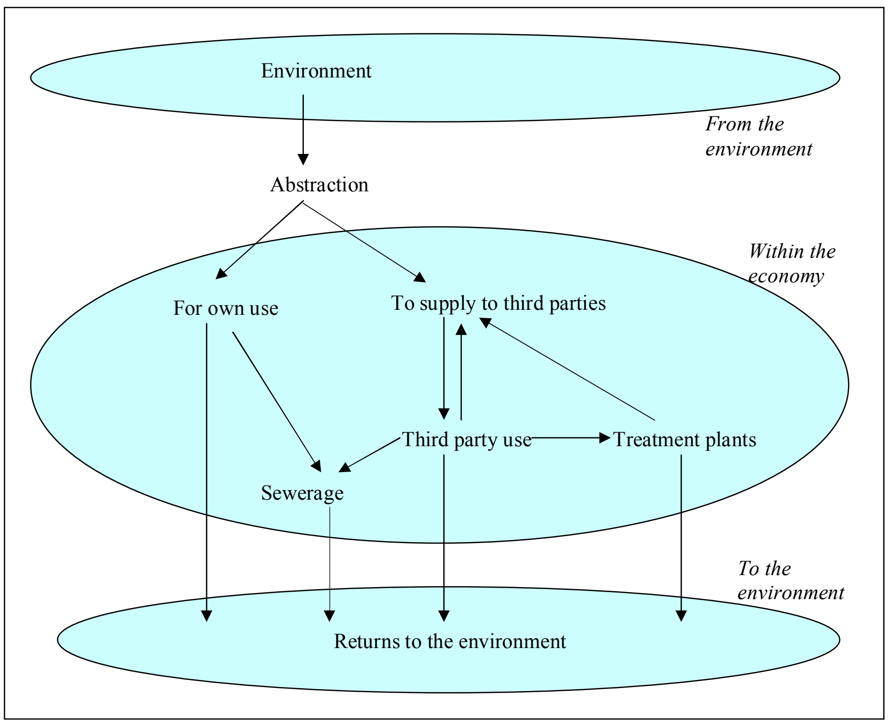
8.87 The economy returns water to the hydrological system through various flows including returns of wastewater to aquifers, rivers, lakes and oceans; returns to soil and water bodies from irrigation activities; and losses in transportation (supply and sewerage pipes etc.). These return flows are an input to the hydrological system and become a resource (even if often of lower quality) for subsequent uses. Imports/exports of water to and from the economy are considered direct inflows/outflows of water through pipes from and to the economies of other territories.

Water accounts: physical flows

8.88 Physical water accounts describe in physical terms the whole system of flows of water between the environment and the economy and within the economy. In describing these flows, it is important to recall the differences between ecosystem inputs, natural resources, products and residuals discussed in chapter III. Water as an ecosystem input or a natural resource belongs to the environmental sphere; once it is abstracted and processed by an industry, it is considered a product and enters the economic sphere. This product can be delivered to either other industries or final consumers. When water is no longer useful in its current state, it is considered to be a residual. Some flows of residuals are recorded within the economy (for example, the routing to water treatment plants) but ultimately all residuals are returned to the environment. Figure 8.3 gives a diagrammatic view of the various stages of supply to be captured in the flow accounts.

8.89 An issue exists regarding how extensive the coverage of water abstracted for own use should be. One option is to say that, in the main, these abstractions simply move the water from one place to another without its really entering the economy and that, therefore, they should be considered "hidden" flows, like mining spoil. Pumping water out of mines, for example, would fall under this heading. The other option is to decide that these flows do enter the economy, in which case the return of the water to the environment would then be recorded as a residual flow. Depending on the situation in a particular country, water used for hydropower generation can be considered water that has been extracted and has returned to the hydrological system and thus entered the economy as a product. The case is similar for water extracted by agriculture for irrigation.

Figure 8.3. Schematic water flows



8.90 One reason for classifying own-account abstractions as products is the increasing implementation of rights to abstract water. When these rights acquire a monetary value, it is difficult not to consider the abstractions as products. For consistency, therefore, all abstractions are here considered products, whether for own use or supply to a third party.

8.91 Flows of water from the environment to the economy, within the economy, and from the economy back to the environment can be described in a supply and use table. The construction of supply and use tables is such that the basic identity "supply equals use" is satisfied separately for flows from the environment, within the economy and to the environment.

8.92 In the case of water as a natural resource, the environment supplies all the water that is directly abstracted by the economy. Once abstracted, water is either used by the extractor or supplied to third parties by (mainly) water companies. Once used, water may be sent to plants that treat and recycle water to third parties or discharge it to the environment. Alternatively, wastewater may be sent to industry "sewage and refuse disposal, sanitation and similar activities" (ISIC 90), through which first some residuals (contaminants) are absorbed and then the wastewater is discharged as a (possibly cleaner) residual to the environment. At every stage in the process, there may be returns of residuals to the environment. These may be deliberate discharges or inadvertent leakages and losses in transport.

8.93 The main industries dealing with water as their principal activity are shown in Box 8.3. Note, though, that this does not constitute a list of industries that are the main abstractors from the environment.

Box 8.3. Description of the main agents that supply and handle water

ISIC 41 Collection, purification and distribution of water

- Includes activities that produce water as the principal product of interest
- Includes desalting of sea water to produce water as the principal product of interest
- Excludes irrigation system operation, which is included in ISIC 014, and treatment of wastewater in order to prevent pollution, which is included in ISIC 90

ISIC 014 Agriculture and animal husbandry service activities, except veterinary activities

- Includes operation of irrigation system for agricultural purposes

The operation of irrigation systems is a specific service providing water to farmers, especially through a network of open-air canals. It should be noted that irrigation water could also be provided by ISIC 41 through normal pipes (as drinking or non-drinking water)

ISIC 90 Sewage and refusal disposal, sanitation and similar activities

- Includes activities of sewage and refusal disposal and other processes of sewage disposal and maintenance of sewers and drains

Source: United Nations, 1990.

Supply table

8.94 Table 8.3, consisting of three parts, provides a numerical example[28] of the supply of water. The first part shows flows from the environment to the economy in total only. The second part shows flows of water (a product) and wastewater (a residual) within the economy. These flows are attributed to industries, final consumers and the rest of the world. The third part shows the eventual return of wastewater to the environment and the agent responsible for the return.

8.95 All abstraction of water is shown as coming from the environment to the economy. It can and should be disaggregated according to whether it is groundwater, surface water or other water (for example, from the sea or brackish water); for some countries further detail may be useful.

8.96 Much water is abstracted for the use of the abstractors. This is especially true in respect of the electricity-generation and agriculture industries. Water that, after abstraction, is distributed to third parties becomes distributed water. It is possible to draw up a two-way matrix showing which industry supplies and which industry uses distributed water.

8.97 In addition to the industries shown in Box 8.3, there are some industries that may supply water that has already been used in the production process to other industries needing lower-quality water in their production process. When data are available, the supply can therefore be further disaggregated depending on the type of water (wastewater, treated water etc.). The supply of water is measured after deducting losses during transportation (distribution) which are considered returns to the environment from the water distributors.

[28] The tables in the present subsection are based very loosely on an actual country example. They are internally consistent but have not been made explicitly consistent with other tables in the SEEAland data set.

8.98 The entries in the third part of the table include all the flows of water from the economy to the environment. Residuals flowing to the environment come from different industries in different ways. The returns of water from agriculture include the runoff of that part of water used for irrigation that is not absorbed and returns to surface water, groundwater and other water. Water used for cooling or hydroelectricity-generation is returned to the environment directly after use. Water treatment plants recycle some water as a product. Another portion is discharged to the environment and can be further disaggregated into treated and untreated wastewater.

Table 8.3. Water supply table

Millions of cubic metres

		Agriculture	Fisheries	Energy	Mining	Manufacturing	Distribution/ irrigation water	Distribution/ mains water	Sewerage	Government	Households	Rest of the world	Environment	Total
From the environment	S1 Total abstractions												3 316.2	3 316.2
	From surface water												2 551.7	2 551.7
	From groundwater												764.5	764.5
	From other water													
	For own use												*1 763.6*	*1 763.6*
	For delivery												*1 552.6*	*1 552.6*
Within the economy	S2 Total supply of distributed water	2.2		1.0		139.3	530.0	653.0		135.3	372.0	5.0		1 837.8
	Water supplied to users	2.2		1.0		6.2	530.0	653.0				5.0		1 197.4
	Of which recycled water			*1.0*		*5.7*						*5.0*		*11.7*
	Waste water to sewerage					133.1				135.3	372.0			640.4
To the environment	S3 Total residuals	152.1	46.0	1 448.6	4.6	17.0	167.1	204.8	640.4	11.5	12.0			2 704.1
	To inland water													
	Returns from irrigation	96.8												96.8
	Treated wastewater		8.0			11.1			613.7		6.0			638.8
	Untreated wastewater	20.0	30.0			5.0				9.3	6.0			70.3
	Cooling water			448.2										448.2
	Water used for hydroelectricity			1 000.0										1 000.0
	Water lost in transport	33.5	8.0	0.4		0.9	167.1	204.8	26.7					441.4
	Other returns of water	1.8			4.6					2.2				8.6
	To the sea													
Consumption		524.1		32.8	0.3	3.2				0.4	56.3			617.1
Total supply		678.4	46.0	1 482.4	4.9	159.5	697.1	857.8	640.4	147.2	440.3	5.0	3 316.2	8 475.2

Note: Constructed example.

8.99 The total supply of water from the rest of the world represents imports of water. Analogously, in the use table, the total use of water by the rest of the world would represent the exports of water, though it happens that in this example there are no exports of water.

8.100 Table 8.3 shows that about three quarters of water abstractions are from surface water and about one quarter from groundwater. Just over half of the abstractions are for own use and just less than half are for distribution to others. The residuals from agriculture comprise wastewater from animal farming and that part of irrigation water that filters through to groundwater instead of being taken up by plants. The process comprising evapotranspiration of irrigation water by soil and vegetation and absorption by other users is called "consumption".

Water flows within the economy

8.101 In order to demonstrate who is supplying water to whom, a matrix of flows of water within the economy can be compiled, as shown in Table 8.4. In this particular case, the main redistribution is of irrigation water to agriculture and of drinking water to households as well as supply of wastewater for treatment to the sewerage industry. The row totals in this table, total supply of distributed water, is equal to the figures in the row "Total supply of distributed water" in Table 8.3.

8.102 If abstractions for own use were considered a product, then these amounts would feature in the diagonal elements of Table 8.4. The small entry for agriculture shown here represents supply from one unit to another within the industry, not strictly own use by the unit making the abstraction.

Table 8.4. Matrix of flows within the economy

Millions of cubic metres

Origin \ Destination	Agriculture	Fisheries	Energy	Mining	Manufacturing	Distribution/ irrigation water	Distribution/ mains water	Sewerage	Government	Households	Rest of the world	Total supply of distributed water
Agriculture	2.2											2.2
Fisheries												
Energy							1.0					1.0
Mining												
Manufacturing					5.2		1.0	133.1				139.3
Distribution/irrigation water	530.0											530.0
Distribution/mains water			9.8		113.1		4.7		110.4	415.0		653.0
Sewerage												
Government								135.3				135.3
Households								372.0				372.0
Rest of the world							5.0					5.0
Total use of distributed water	532.2		9.8		118.3		11.7	640.4	110.4	415.0		1 837.8

Note: Constructed example.

Use table

8.103 Table 8.5 is the counterpart to Table 8.3 and presents the use of water. In this table, the abstractors of water are shown by industry and sector. Usually the largest abstractors will include agriculture and electricity-generation, which abstract for own use, as well as the water supply industries which abstract in order to deliver to third parties. As before, disaggregation among surface water, groundwater and other water is desirable.

8.104 The total use of distributed water within the economy is equal to the total supply of distributed water. Total water use can be determined by adding abstractions for own use to the amount received from distributors as products. It is helpful to analyse these total uses by purpose. For example, the use of water by agriculture could be further classified as water for irrigation, for animal husbandry, for sanitary purposes and for other purposes. The use of water could be also disaggregated by purpose according to data availability and specific country needs. In Denmark, for example, the use of water is distinguished as being for potable water supply, industrial cooling, use in production processes and other uses. Since this decomposition may not be relevant to all industries, a number of more detailed satellite accounts could be constructed to the extent that there is demand for them and sufficient data are available (Bie and Simonsen, 1999). The Australian Bureau of Statistics (2000) distinguishes the use of water according to whether it is reused in the production process, after having been treated to some extent, or directly supplied through mains. Namibia and Botswana classify water use according to whether it is provided by town systems or rural systems.

8.105 Owing to the particular characteristics of water use for hydroelectricity and cooling in conventional or nuclear power plants (including the use of sea water for this purpose), the use of water in the generation of electricity can be accounted for separately. In the present example, about half of total abstractions are used in the generation of electricity. Of the remainder, the major use is for irrigation, either through own-account abstractions or via the distribution of irrigation water to other users.

Table 8.5. Water use table

Millions of cubic metres

		Agriculture	Fisheries	Energy	Mining	Manufacturing	Distribution/irrigation water	Distribution/mains water	Sewerage	Government	Households	Rest of the world and sea	Environment	Total
From the environment	U1 Total abstractions	146.2	46.0	1 472.6	4.9	41.2	697.1	846.1		36.8	25.3			3 316.2
	From surface water	95.9	46.0	1 470.5		20.2	597.1	322.0						2 551.7
	From groundwater	50.3		2.1	4.9	21.0	100.0	524.1		36.8	25.3			764.5
	From other water													
	For own use	*144.0*	*46.0*	*1 471.6*	*4.9*	*35.0*				*36.8*	*25.3*			*1 763.6*
	For delivery	*2.2*		*1.0*		*6.2*	*697.1*	*846.1*						*1 552.6*
Within the economy	U2 Total use of distributed water	532.2		9.8		118.3		11.7	640.4	110.4	415.0			1 837.8
	Water received by users	532.2		9.8		118.3		11.7		110.4	415.0			1 197.4
	Of which recycled water							*11.7*						11.7
	Waste water collected by sewerage								640.4					640.4
To the environment	U3 Total residuals												2 704.1	2 704.1
	To inland water													
	Returns from irrigation												96.8	96.8
	Discharge wastewater after treatment												638.8	638.8
	Discharge of untreated wastewater												70.3	70.3
	Cooling water												448.2	448.2
	Water used for hydroelectricity												1 000.0	1 000.0
	Water lost in transport												441.4	441.4
	Other returns of water												8.6	8.6
	To the sea													
Consumption													617.1	617.1
Total use		678.4	46.0	1 482.4	4.9	159.5	697.1	857.8	640.4	147.2	440.3		3 321.2	8 475.2

Note: Constructed example.

8.106 The supply and use tables can be combined into a single table, as in Table 8.6. There are three ways in which water becomes available for use within the economy: it can be abstracted for own use, it can be abstracted for delivery to others and it can come from recycling or imports from another economy. In respect of each of these sources, there may be losses before the water reaches the intended user, though in Table 8.6 losses are shown only for the first two sources.

8.107 Water that reaches the user may be returned to a recycling plant, exported, discharged directly to the environment or discharged to the environment via the sewerage industry. Water that is not returned to water bodies because it is absorbed by plants (irrigation water), domestic animals, humans or in industrial processes appears as consumption, the balancing item in the table. This item may also include a small amount of water accumulated in inventories of products such as beverages.

8.108 Box 8.4 shows how the entries from the supply and use tables can be reconciled in Table 8.6. showing the main stages of water flows through the economy.

Table 8.6. Main stages of water flows through the economy

Millions of cubic metres

	Agriculture	Fisheries	Energy	Mining	Manufacturing	Distribution/irrigation water	Distribution/mains water	Sewerage	Government	Households	Rest of the world and sea	Total
Total abstractions	146.2	46.0	1 472.6	4.9	41.2	697.1	846.1		36.8	25.3		3 316.2
For own use	144.0	46.0	1 471.6	4.9	35.0				36.8	25.3		1 763.6
Leakages during use	33.5	8.0	0.4		0.9							42.8
Available for own use	110.5	38.0	1 471.2	4.9	34.1				36.8	25.3		1 720.8
For delivery	2.2		1.0		6.2	697.1	846.1					1 552.6
Leakages during distribution						167.1	204.8					371.9
Recycled water and imports							11.7				5.0	16.7
Water supplied to users	2.2		1.0		6.2	530.0	653.0				5.0	1 197.4
Water received by users	532.2		9.8		118.3		11.7		110.4	415.0		1 197.4
Water available for use	642.7	38.0	1 481.0	4.9	152.4		11.7		147.2	440.3		2 918.2
Recycled water							11.7					
Waste water to sewerage					133.1				135.3	372.0		640.4
Returns from irrigation	96.8											96.8
Treated wastewater		8.0			11.1					6.0		25.1
Untreated wastewater	20.0	30.0			5.0				9.3	6.0		70.3
Cooling water			448.2									448.2
Water used for hydroelectricity			1 000.0									1 000.0
Other returns of water	1.8			4.6					2.2			8.6
Consumption	524.1		32.8	0.3	3.2				0.4	56.3		617.1

Note: Constructed example.

Box 8.4. Reconciliation of entries in tables 8.3, 8.5 and 8.6

Row	Title	Relation to other rows	Relation to other tables
1	Total abstractions		Use table: total abstractions
2	For own use		Use table: abstractions for own use
3	Leakages during use		Supply table: water lost in transport except for losses by distribution
4	Available for own use	Row 2 - row 3	
5	For delivery	Row 1 - row 2	
6	Leakages during distribution		Supply table: water lost in transport by distribution
7	Recycled water and imports		Matrix of flows within the economy
8	Water supplied to users	Row 5 - row 6 + row 7	Supply table: water supplied to users
9	Water received by users		Use table: water received by users
10	Water available for use	Row 9 + row 4	
11	Recycled water	Row 7 (excluding imports)	
12	Waste water to sewerage		Supply table: water water to sewerage
13	Returns from irrigation		Supply table: returns from irrigation
14	Treated wastewater		Supply table: treated wastewater
15	Untreated wastewater		Supply table: untreated wastewater
16	Cooling water		Supply table: cooling water
17	Water used for hydroelectricity		Supply table: water used for hydroelectricity
18	Other returns of water		Supply table: other returns of water
19	Consumption	Row 10 - rows 11 to 18	Supply table: consumption

Asset accounts for water

8.109 Asset accounts for water detail how the stocks of water at the beginning of the accounting period, as affected by flows of water between the environment and the economy and transfers of water internal to the hydrological system, become the stocks of water at the end of the accounting period.

8.110 Before embarking on the compilation of asset accounts for water, the definition of water stock has to be clarified. For groundwater, reservoirs and lakes, it is conceptually simple to measure stocks. For rivers, the stock of water is not well defined owing to the "flowing" nature of the resource. In order that consistency may be maintained with the other water resources, the stock of water in a river is here measured as the volume of the riverbed. This is the measure that has been used by Spain, France, Chile and the Republic of Moldova. However, the volume of a riverbed is not always a good measure of water stocks, especially for ephemeral rivers. An alternative solution is to consider annual runoff into the river or the mean annual runoff in a country that is subject to very large annual variation.

8.111 Annual runoff is the total volume of water that flows during a year, and usually refers to the outflow of a drainage area or river basin. For perennial rivers, runoff is measured at the lowest point downstream, sometimes close to the estuary. Hence, it includes all flows that have taken place upstream. For rivers crossing national borders, runoff up to the point of entry into the country should be deducted.

8.112 Mean annual runoff is defined as the average net annual rainfall under natural conditions. The result depends on the runoff regimes for each river basin. When flow increases downstream and the flow is greatest at the mouth of the river basin, the measure of the mean annual runoff applies to the river basin. When the flow in rivers decreases downstream, often with little or no outflow from the river basin, the mean annual runoff is measured as the combined mean annual runoffs of each of the major catchment areas in the river basin, calculated at the point where the flow is greatest and excluding runoff from upstream basins (Australian Bureau of Statistics, 2000; Australian Water Resources Council, 1987).

8.113 Using average flows over a period of time as a proxy for stock figures presents problems in the asset accounts, as some of the flows in the table may be already included depending on where the river flow is measured. In such a case, the flows in the asset account should be modified accordingly so as to avoid double counting.

8.114 Table 8.7 represents an asset account for surface water and groundwater resources. As explained above, the classification of water resources does not include water in soil and vegetation, permanent snowfields and ice. In this case, the accounts measure the precipitation that reaches surface water and groundwater. The runoff to surface water and infiltration to groundwater are therefore net of evapotranspiration.

8.115 The opening and closing stocks represent the quantity of water, in cubic metres, at the beginning and end of the accounting period. The changes in stocks during the accounting period can be caused by human activities (abstraction and return of water to the environment) and by natural process (precipitation, evapotranspiration, natural inflows and outflows to other rivers etc.). In Table 8.7 only evapotranspiration from surface water bodies is shown, since the precipitation is recorded net of the evapotranspiration that occurs before water reaches the surface water. The detailed description of the table entries is as follows:

> ***Abstraction*** shows the total volume of inland water abstracted in a year (since in the constructed example, there is no abstraction from other sources, abstraction is equal to the total U1 in Table 8.5).
>
> ***Residuals*** represent the total volume of water in the accounting period returned to the environment (that is, inland water). They are equal to the part of S3 in Table 8.3 that is returned to inland water. In the constructed example, the returns to the sea are zero, thus the residuals in Table 8.7 are exactly equal to the total residuals (S3) in Table 8.3. They can be disaggregated by major activity as shown. If data are available, the returns of water could also be disaggregated by type of water returned.

Precipitation consists of all precipitation. When the category "water in soil" is not included in the table, the figures for precipitation are net of evapotranspiration. Hydrologists call this "efficient precipitation". It represents the part of the total annual precipitation that reaches the lakes, rivers, reservoirs and groundwater whether directly, via runoff, or by infiltration.

Table 8.7. Asset account for inland water

Millions of cubic metres

		EA.131 Surface water			EA.132 Groundwater	Total
		EA.1311 Reservoirs	EA.1312 Lakes	EA.1313 Rivers		
Opening stocks		1 500	2 700	300	150 000	154 500
Abstraction (-)		1 580		972	765	3 316
Residuals (+)	Returns from irrigation			47	50	97
	Wastewater			441	268	709
	Lost water in transport			141	300	441
	Others			1 457		1 457
Net precipitation (+)			100	2 175		2 275
Inflows (+)				9 000	1 100	10 100
Net natural transfers (+/-)		1 650	110	-1 715	- 45	0
Evaporation from water bodies (-)		170	216	133		519
Outflows (-)	To other country			2 300	380	2 680
	To the sea			8 000	1 000	9 000
Other volume changes	Due to natural disaster					
	Discovery (+)					
	Others					
Closing stocks		1 400	2 694	300	149 229	153 623

Note: Constructed example.

Inflows represent the total volume of water in the accounting period that enters the territory of reference. For a river that enters the territory of reference, the inflow is the total quantity at its entry point. If a river borders two countries without finally entering either of them, each country could attribute a percentage of the flow to its territory. If no formal convention exists, a practical solution is to attribute 50 per cent of the flow to each country. In the situation in which rivers cross borders several times, it is necessary to take account of outflows at exit as well as inflows at entry.

Net natural transfers for a water resource are defined as the difference between the inflows to one type of water resource from all the others and the outflows from the same water resource to all the others. A separate matrix showing these transfers can be compiled, as indicated in Table 8.8.

Evapotranspiration is the total volume of evapotranspiration from the ground, wetlands and natural water bodies and transpiration of plants where the soil is at its natural water content. This is a hydrological concept. It excludes the evapotranspiration generated by all human intervention except for non-irrigated agriculture and forestry.

Outflows represent the volume of water that leaves the territory of reference during the accounting period. This flow could be disaggregated depending on whether the flow is to other territories or to the sea.

Other changes in volume include all the changes in the stocks of water that are not specified elsewhere in the table. This item can be either estimated or calculated directly.

8.116 Some countries may not have separate information on each flow. Some of the flows can be combined according to data availability. Table 8.7 allows for the calculation of indicators such as total renewable water resources, total actual renewable water resources, total non-renewable water, and dependable water.

Total natural renewable water resources are the sum of the average annual flow of rivers and recharge of groundwater generated from endogenous precipitation and the natural flow originating outside the country (Food and Agriculture Organization of the United Nations, 2000).

Total actual renewable water resources are the sum of the internal renewable water resources and natural incoming flow originating outside the country, taking into account the quantity of flow reserved to upstream and downstream countries through formal or informal agreements (Ibid.).

Dependable water are defined as the portion of the surface-water resource that can be depended upon for annual water development during a period of time, which varies according to national situation but is usually 19 out of 20 (or 9 out of 10) consecutive years.

Total non-renewable water is the volume of water that is not renewable by endogenous processes during the hydrological cycle. It includes fossil groundwater generated in the geologic eras of the earth's formation as well as a large part of the water in lakes whose replenishment rate is very small.

8.117 Table 8.8 gives a rather simplistic numerical example of transfers between water resources. These are natural flows that are determined by processes of infiltration from surface water to groundwater, processes of groundwater discharge to surface water, and so on.

Table 8.8. Transfers between water resources

Millions of cubic metres

Origin:	Destination:	EA.131 Surface water: Reservoirs	EA.131 Surface water: Lakes	EA.131 Surface water: Rivers	EA.132 Groundwater	Total outflows
EA.131	Reservoirs					0
	Lakes					0
	Rivers	1 650	110		220	1 980
EA.132 Groundwater				265		265
Total inflows		1 650	110	265	220	2 245
Net natural transfers		1 650	110	-1 715	- 45	0

Note: Constructed example.

Water in soil

8.118 As mentioned above, the SEEA classification does not explicitly show water contained in soil. Nevertheless, this can be an important source of water and is referred to by agronomists as the "useful reserve" of water. In order to show the consequences of recording this useful reserve explicitly, Table 8.7 can be amended to show an extra column for water in soil. Such a presentation of the accounts permits an assessment of the relative importance of natural (spontaneous) evapotranspiration versus evapotranspiration artificially evoked in response to economic activity (for example, the use of water for cooling). Another option in the account is to include water in permanent snow and ice. France, Spain, Chile and the Republic of Moldova have compiled accounts including both permanent snow and ice and water in soil and vegetation.

8.119 When a column for water in soil is included, precipitation is measured gross of evaporation and shown as increasing this stock of water which (mainly) then evaporates from the land, although some finds its way into rivers. When such a column is not shown, the flows to land are consolidated with those for rivers. Table 8.9 shows the relevant entries from Table 8.7 in the consolidated version and how these may appear in an extended table.

Table 8.9. Showing water in soil explicitly

Millions of cubic metres

Consolidated version		Extended version	
	Rivers	Rivers	Water in soil
Net precipitation	2 175	175	12 000
Net transfers	-1 715	285	-2 000
Evapotranspiration	133	133	10 000

Note: Constructed example.

Seasonal and geographical issues

8.120 One of the issues that has to be taken into account when compiling water accounts is the seasonal aspect. Water availability may change significantly over the seasons of the year, with water being abundant during certain periods of the year and scarce in others. This variability is usually not reflected in yearly accounts. Depending on data availability and the length of the water cycle, it may be useful to compile water accounts more frequently so as to reflect water availability and water demands in different seasons.

8.121 Some countries experience long-term cyclical patterns in respect of water, sometimes going several years without significant rainfall. In such cases, indicators that are useful for water-abundant areas may be of limited application.

8.122 Similar reservations apply in the context of the spatial dimension of water. Water may be widely available in certain locations, but absent in others. In Botswana, for example, there is only one river in the extreme north-west of the country (the Okavango delta). While this represents a huge amount of freshwater, all of which comes from catchment areas outside the country, it is not available for commercial exploitation hence the country as a whole is seriously water-stressed, much of it being desert. For such a country, the indicators shown under Table 8.7 would be seriously misleading. As with many indicators, therefore, care in their use has to be taken when there are particular characteristics of a country that invalidate their usefulness.

8.123 Water accounts compiled at the national level do not show regional variability. In order to identify this variability, it would be useful to link water data to regional economic accounts. Although, water data are sometimes available by watershed, these do not fit tidily into administrative regions where rivers may often mark the border between one region and another.

Water-quality accounts

8.124 The use to which water can be put depends crucially on its quality. For example, water used for hydroelectric power-generation, industrial purposes and transportation does not require high standards of purity, whereas other uses (drinking, recreation, habitat for aquatic organisms etc.) rely on higher levels of purity. Once quality classes are defined, water-quality accounts can be constructed following the same general structure as an asset account in physical terms with quality as simply another dimension. The accounts show the opening and closing stocks together with the changes in stocks during the accounting period for each quality class. Table 8.10 shows the general structure for quality accounts.

Table 8.10. Quality accounts

	Quality classes				
	Q1	Q2	Q3	Q4	Q5
Opening stocks					
Changes in stocks					
Closing stocks					

8.125 Quality classes can be defined in various ways depending on the particular interest of the country or region concerned. In Australia, for example, groundwater assets are divided into four quality categories indicating the potential use of the resource. The quality classes are based on the total dissolved solids, which are measured in milligrams per litre (mg/l). Good-quality water for human use has a salinity of less than 500 mg/l with an upper limit of 1,500 mg/l, which is also the limit for crop irrigation. Salinity of water for livestock is preferably in the lower ranges, but some salt-tolerant livestock can bear water salinity up to 15,000 mg/l. For coarse industrial process, such as ore processing, the upper limit may be much higher. By comparison, sea water has a salt concentration of about 35,000 mg/l.

8.126 Quality classes of surface waters can be defined according to the level of pollution with organic matter, inter alia, by BOD (biochemical oxygen demand), by COD (chemical oxygen demand), or by other measures such as ammonium ion (NH_4^+) concentration. Usually, for surface waters, a number of quality classes are defined at the national level. Table 8.11 shows the accounting structure for the accounts of the quality of rivers in France for the years 1992 and 1994. The quality classes are referred as 1A, 1B, 2, 3 and NC (not classified), with 1A being the highest-quality and 3 the lowest-quality class.

8.127 The general structure of quality accounts is simple conceptually; however, it presents numerous problems of measurement. Temporal and spatial considerations play important roles in respect of water quality and should be taken into account when compiling quality accounts, especially if the accounts are used for water management. The quality of a river, for example, might increase enormously during particular weather conditions, and decrease rapidly when the conditions change. Periodic variations, such as time of day, season and year, are complemented by sporadic changes in quality due, for example, to a sudden catastrophe, such as a chemical spill. In addition, a long river may contain water of different quality at various points, with quality often being high at the source of the river and low at the mouth.

Table 8.11. Quality of watercourses (organic matter indicator), France, by size class of watercourses

Thousands of kilometres of standard river (kmsr)

Group of water courses	1992 state					Differences by quality class					1994 state				
	1A	1B	2	3	NC	1A	*1B*	*2*	*3*	*NC*	1A	1B	2	3	NC
Class A rivers	5	1 253	891	510	177	3	*336*	*9*	*- 183*	*- 165*	8	1 583	893	358	12
Class B rivers	309	1 228	1194	336	50	*16*	464	- 275	- 182	- 22	325	1 691	919	154	28
Class C rivers	260	615	451	128	47	*44*	*130*	- 129	- 17	- 28	306	749	322	110	18
Streams	860	1 464	690	243	95	*- 44*	*- 176*	*228*	*15*	- 23	810	1 295	917	258	72

Source: Institut français de l'environnement (1999).

Note: The figures in the middle column (in italics) do not in all cases match precisely the calculated difference between the 1992 and 1994 states of the rivers in question. This is because of difficulties in comparing certain groups of watercourses in some watershed basins with respect to the two points in time.

8.128 Another issue relates to the measurement of stocks of water of a certain quality. Water quality is measured at a single point and it is difficult to aggregate such measurements so as to represent large regions such as big lakes, rivers and even drainage regions. This problem is particularly difficult for rivers owing to the flowing nature of the water. One measure that has been proposed by the French Environment Institute (IFEN) and used by several countries is the kilometre of standard river (kmsr), which is a standardized unit of account representing a river stretch of one kilometre with a water flow of one cubic metre of water per second. This measure entails multiplying each stretch of a river containing a certain quality of water by its flow. The river is thus divided into different sections with different quality classes, whose water flow can be aggregated without double counting.

8.129 Although the major changes in stocks of water are due to abstractions and returns, it will not be practicable to relate changes in water quality to these additions and subtractions from stock levels, unless very detailed information on the quality of abstractions and returns is available. Linking the quality of the river (expressed in standard river kilometres weighted by quality indices) to the flow of residuals and the flow of water that have generated this quality requires using analytical hydrological models. Such models exist but they are very data-demanding and applied more for local than for national use.

8.130 On the basis of the quality accounts, global indices of water quality have been calculated by France and Chile.

3. Monetary accounts

8.131 The present section covers monetary valuation of flows, environmental expenditure and resource management accounts, and issues related to the valuation of water resources, taking into account the particular nature of water.

Monetary valuation of flows

8.132 The physical supply and use tables presented in Table 8.3 and Table 8.5 have monetary counterparts. Water supply in monetary units records the major economic output of industries related to water and imports. In particular, it includes output of production of drinking water, non-drinking water, irrigation water, production of sewage removal and treatment services. The water use table in monetary units records the use of water by different economic agents.

8.133 There is a discussion in section VII.E on the various methods of placing a monetary value on water flows. However, of equal concern are the accounts concerned with managing and protecting water resources.

Environmental protection and management activities

8.134 As described in chapter V, environmental protection and management activities are considered under four main categories:

(a) Environmental protection activities;

(b) Natural resource management and exploitation activities;

(c) Environmentally beneficial activities;

(d) Minimization of natural hazards.

Environmental protection activities

8.135 Environmental protection activities related to water involve activities of "wastewater management" and of "protection and remediation of soil, groundwater and surface water" in CEPA 2000. Wastewater management is mainly undertaken as part of the ISIC 90 ("Sewage and refusal disposal, sanitation and similar activities") as well as treatment of wastewater as an ancillary activity. For soil and groundwater, this includes activities which target the reduction or elimination of polluting substances that may be applied to soil and percolate into groundwater, decontamination of soil and activities related to monitoring and controlling soil pollution.

Management activities

8.136 Management activities cover primary, secondary and ancillary activities related to water management.

8.137 Management expenditure accounts for primary water activities include the production and generation of income accounts for ISIC 014 ("operation of irrigation systems"), ISIC 41 ("Collection, purification and distribution of water") and part of ISIC 75 ("Public administration of services"). These accounts may contain supplementary information regarding fixed capital and labour inputs.

8.138 Management expenditure accounts can be compiled for secondary and ancillary water-related activities, that is, those activities carried out by industries different from those under ISIC 01, 41 and 75. These activities include, for example, direct abstraction of water by manufacturing industries for cooling purposes or by final consumers for own use. Such accounts cover expenditures related to abstraction and purification of water. They include information on current expenditures such as intermediate consumption, compensation of employees, taxes and subsidies related to water, on capital expenditure and, when possible, on consumption of fixed capital, stock of fixed assets and labour inputs.

Environmentally beneficial activities

8.139 Environmentally beneficial activities are those activities that may be primarily undertaken for economic reasons but yield substantial environmental benefits even though the primary purpose is not environmental protection. Environmentally beneficial activities related to water include those activities aimed at saving water, whether for final consumers, industries, services or agricultural users. They may take the form of investment (irrigation systems, facilities and appliances to reduce water consumption, recycle water etc.) or the use of products adapted for lower water consumption, for example, specially adapted washing machines (Eurostat, 1994).

Minimization of natural hazards

8.140 Expenditures to minimize natural hazards related to water include expenditures to prevent flooding, such as on the construction of dams to restrict water flow, management of water retention areas, measures to avoid droughts and so on. These accounts may provide an indication of the effects of alteration of landscapes and water systems or global warming.

D. Accounts for wooded land, timber and forest products

1. Introduction

8.141 The present subsection considers the compilation of accounts in greater detail for wooded land (SEEA asset category EA.23) and for the products coming from or related to it. These cover cultivated and non-cultivated timber and non-wood products and environmental services, which fall into the SEEA asset categories EA.1411, EA.1412, EA.1422, EA.1442 and EA.313. Some of the accounts are described in both physical and monetary terms and some in physical terms only.

8.142 Subsection 2, which concentrates on physical accounts for forested land, introduces a more detailed classification such as may be used for an in-depth analysis of the forestry industry and its environmental implications. Subsection 3 applies this extended classification to the physical accounts for timber, both standing and harvested.

8.143 The monetary accounts for wooded land and for timber do not follow the physical accounts exactly. The separation of land and timber which can be observed in the physical accounts may not be as easy to achieve or as useful in monetary accounts. Subsection 4 discusses valuation techniques for timber and how monetary accounts can be constructed and drawn into the aggregate economic accounts.

8.144 Subsection 5 covers accounts for all forest products. To the information on harvested timber, described in subsection 4, information is added for non-wood products in both physical and monetary terms.

8.145 Current monetary expenditures on forest management, conservation and protection can also be linked to the forested land area concerned even though they may have no physical counterparts. These expenses can be presented in ways compatible with the accounts detailed in chapter V. They are described in subsection 6.

8.146 Subsection 7 looks at some of the supplementary information, often of an ecological nature, that is collected by the Food and Agriculture Organization of the United Nations (FAO) and the World Conservation Union (IUCN). The aspects mentioned here include ecofloristic zones, biodiversity, carbon-binding and the status of protection of forests.

8.147 Subsection 8 looks at the compatibility of different international data sources.

2. Physical accounts for forested land

8.148 The present subsection describes how detailed accounts for forested land may be developed, using Finnish data for illustration.

Extending the classification of wooded land

8.149 The standard SEEA asset classification divides wooded land and associated surface water (EA.23) first into cultivated and non-cultivated forested land. Non-cultivated forested land may be further subdivided between those previously harvested and virgin forested land. As illustrated below, a country may develop a more extensive classification when forestry is an important industry and forested land an important type of land cover.

8.150 The definitions used in national forestry studies differ between countries, but for the purpose of international comparisons some international definitions have been developed. The definitions below are from the ECE/FAO Temperate and Boreal Forest Resource Assessment 2000, commonly referred to as TBFRA-2000 (United Nations Economic Commission for Europe and Food and Agriculture Organization of the United Nations, 2000). Similar definitions are used by FAO for all ecofloristic zones in the Global Forest Resources Assessment 2000, also known as FRA-2000 (Food and Agriculture Organization of the United Nations, 2001).

8.151 **Wooded land** is divided first between forests and other wooded land. Both categories exclude land predominantly used for agricultural purposes.

8.152 **Forested land** is defined as land with tree crown cover (or equivalent stocking level) of more than 10 per cent and an area of more than 0.5 hectares. The trees should be able to reach a minimum height of five metres at maturity in situ. Forested land includes:

(a) Young natural stands and all plantations established for forestry purposes that have yet to reach the crown density of 10 per cent or tree height of five metres;

(b) Areas normally forming part of the forested land area that are temporarily unstocked as a result of human intervention or natural causes but expected to revert to forest;

(c) Forest roads, cleared tracts, firebreaks and other small open areas, as well as forest nurseries and seed orchards, that constitute an integral part of the forest;

(d) Forested land in national parks, nature reserves and other protected areas such as those of special environmental, scientific, historical, cultural or spiritual interest;

(e) Windbreaks and shelter belts of trees with an area of more than 0.5 hectares and a width of more than 20 metres;

(f) Rubber wood plantations and cork oak stands.

8.153 The primary use of forested land is forestry, which includes activities related to the management of forested land and other wooded land for the production and supply of wood and/or other goods and services. This definition of forestry differs from that used in the ISIC classification, in which forestry is restricted to timber production and related activities.

8.154 **Other wooded land** is defined as land with a tree crown cover (or equivalent stocking level) of either 5-10 per cent of trees able to reach a height at least five metres at maturity in situ or a crown cover of more than 10 per cent of trees not able to reach a height of five metres at maturity in situ (for example, dwarf or stunted trees) and shrub or brush cover. Areas having tree, shrub or bush cover that is less than 0.5 hectares in size and less than 20 metres in width are excluded and classified as "other land".

8.155 In the next stage, forested land is subdivided according to its availability for wood supply.

8.156 **Forested land available for wood supply** covers areas where legal, economic or environmental restrictions do not have a significant impact on the supply of wood. It includes areas where harvesting of timber is not taking place, for example, because of long-term utilization plans or intentions.

8.157 **Forested land not available for wood supply** includes areas where legal, economic or environmental restrictions prevent any significant wood production. Legal and/or environmental restrictions refer to protection for environmental and biodiversity conservation and other protection, including restrictions to ensure protection against soil erosion, avalanches and so on, and for special environmental, scientific, historical, cultural or spiritual purposes. Economic restrictions appear in areas where physical productivity or wood quality is too low or harvesting and transport costs are too high to warrant wood harvesting, apart from occasional cuttings for own consumption.

8.158 Forested land available for wood production can be further subdivided according to the authenticity or naturalness of the forest. Such characteristics are very closely related to those encompassed in the definitions of cultivated and natural assets described in chapter VII. As discussed below, this distinction is very important, as it has an impact on the calculation of production of the forest industry. The 1993 SNA treats natural growth of cultivated assets as a process of production, and hence it is accounted for as output of the forest industry. Natural growth of non-cultivated forest is, in contrast, a natural process and therefore not treated as a productive activity. One classification useful for separating cultivated from non-cultivated forested land (and also for other purposes) is the classification of forests as natural, semi-natural or plantations. The FAO classification of forests comprises:

(a) **Natural forests:** forests with natural species and ecological processes and for which there has been continuity of ecological processes over a very long period of time. The time period of continuity is sometimes quoted as being of more than 200 years but this may not be relevant for all types of forests;

(b) **Semi-natural managed forests:** forests in which management has substantially altered the structure and ecological processes but in which growth is still mainly a natural process with no regular and continuous human intervention;

(c) **Plantations:** forests for intensive fuel or industrial wood production, planted or artificially regenerated and made up of exotic (non-indigenous) species and/or monocultures.

8.159 Although the definitions in the 1993 SNA and FAO classifications are a result of different considerations, the definition of natural forests in the FAO classification is very close to that in the SNA. Timber in natural forests is clearly non-cultivated and plantations are cultivated according to the SNA definition. Natural and cultivated aspects are mixed in semi-natural forests, since management does not necessarily substantially alter the ecological processes or end the continuity of those processes of the forests. According to the more stringent definition of cultivated biological assets proposed in chapter VII for use in both the SEEA and the SNA, most semi-natural forests would be classified as non-cultivated in both systems. This is the assumption made in the remainder of this subsection.

8.160 The degree of naturalness of forests is difficult both to define and to measure precisely. This is a new area in forestry statistics and results may not be fully comparable between countries. Eurostat (1999) discusses this problem based on test calculations for several EU countries and the ECE/FAO discusses it in the context of the results of TBFRA-2000 (United Nations, Economic Commission for Europe and Food and Agriculture Organization of United Nations, 2000). In practice, it is often difficult to make a reliable separation of, on the one hand, the natural growth of timber that occurs in cultivated forests and, on the other hand, the wood removed from the non-cultivated forest. When no clear-cut data sources are available, it may be useful to treat all forest as either cultivated or non-cultivated. In countries where most of the cultivated forests are plantations and/or specific (non-indigenous) species, it is usually easier to distinguish between cultivated and non-cultivated forests.

8.161 Forested land not available for wood production can be further subdivided into areas that are **strictly protected** (IUCN classes I and II) and **forested land under economic restrictions**. This disaggregation is useful, since changes in economic restrictions may occur with increasing market prices, improved technology, and the entry of new human settlements and of road networks into areas previously isolated.

8.162 Forests can also be classified on the basis of predominant tree types: **coniferous** (class Gymnospermae*),* **broadleaved** (class Angiospermae), **bamboo** (family Graminae) and **palms** (family Arecaceae). Forests are assigned to these categories if more than 75 per cent of the tree crown cover consists of the tree species mentioned. In **mixed forests**, none of the species groups accounts for more than 75 per cent of the tree crown area.

8.163 A hierarchy for classifying forested land, that is alternative to the standard SEEA classification is shown schematically in Table 8.12.

Table 8.12. Alternative hierarchy for classifying wooded land

Forests			
	Forests available for wood supply		
		Natural forests	
			Coniferous
			Broad-leaved
			Bamboo, palms etc.
			Mixed forests
		Semi-natural forests	
			Coniferous
			Broad-leaved
			Bamboo, palms etc.
			Mixed forests
		Plantations	
			Coniferous
			Broad-leaved
			Bamboo, palms etc.
			Mixed forests
	Forests not available for wood production		
		Strictly protected	
			Coniferous
			Broad-leaved
			Bamboo, palms etc.
			Mixed forests
		Under economic restrictions	
			Coniferous
			Broad-leaved
			Bamboo, palms etc.
			Mixed forests
Other wooded land			

8.164 It may be that not all these headings would be applicable in a given country. For example, in a country such as Finland there is no need to include the category for bamboo, palms etc. since these plants do not grow at that latitude. There may also be data limitations in implementing this scheme. For example, it may be the case that the dominant species cannot be cross-classified by the “naturalness” of the forest. Productivity and species composition may differ across a country, owing to climatic conditions or soil type, say. Regional forest accounts may be a very useful way of dealing with this. For example, France has established separate accounts for the main forest regions (see Eurostat (2000b) for a summary).

Physical accounting entries for forested land

8.165 Changes in forested land may be brought about by:

(a) Increases in the stock (afforestation and natural expansion);

(b) Decreases in the stock (deforestation and degradation);

(c) Changes in land classification and reassessment of stocks.

Afforestation and natural expansion

8.166 The stock of forested land may increase because of the establishment of new forest on land that was previously not classified as forested land or as a result of silvicultural measures or natural expansion. Additionally, land classified as other wooded land may be shifted to forested land as a result of silvicultural measures or natural restoration, including restoration after shifting cultivation.

8.167 Total increase in forested land can also be classified as either man-made afforestation (silvicultural measures including planting and seeding) including plantations, or natural expansion resulting from natural seeding, sprouting, suckering or layering.

8.168 Forest renewal by natural or silvicultural measures after clear-cutting does not qualify as an increase in forested land. This land remains classified as forested land except when clear-cutting is preliminary to putting the land to an alternative use such as agriculture or construction.

Deforestation and degradation

8.169 The stock of forested land may decrease because of the complete loss of tree cover and transfer of forested land to uses other than forestry (as agricultural land, land under buildings, roads etc.) or to no identifiable use. This is usually a result of deforestation arising from human activities. The stock may also be reduced because the forested land is degraded to a point where tree cover falls below 10 per cent and the land thus becomes classified as other wooded land. Degradation may appear for natural reasons, for reasons of human activity or for a combination of reasons.

8.170 Total removals of standing timber by felling do not produce decreases in forested land if the use of the land does not change after felling.

Changes in classification and reassessment of stocks

8.171 Changes in classification due to economic decisions include the decision to protect, or to cancel protection of, forested land; the decision to put the land to other uses; and changes in the conditions and infrastructure affecting forested land on which harvesting is currently limited owing to economic conditions (distance from markets, prices etc.).

8.172 Reassessment of the stock due to improved knowledge includes recognition of new resources and adjustments of area and volume estimates due to new data and estimation methods.

8.173 Catastrophic events (fires, storms, avalanches etc.) affect the volumes of standing timber on forested land, although they do not necessarily decrease the forested land area. Areas where fires and catastrophic events decrease the crown cover below the level defined for forested land should be separately identified.

8.174 Changes in forested land can also be divided into those based on economic decisions and those due to natural causes. Changes due to economic decisions consist of afforestation and deforestation, degradation, reassessment of the stock and changes in classifications. Changes due to natural causes encompass natural extension, degradation and natural catastrophic events.

An example of a physical account for forested land

8.175 An example of a physical account for forested land is shown in Table 8.13. Here the classification and accounting entries described above have been applied to Finnish data for the years 1990 to 1995.

Table 8.13. Forested land area by type

Thousands of hectares

	Forest land	***Available for wood supply***	Natural forests	Semi-natural forests	Plantations	***Total***	Conifers	Broadleaved	***Total***	***Not available for wood supply***	Conifers	Broadleaved	***Total***	**Total forest land**
Opening area 31.12.1990			480	21 222	0	21 702	19 857	1 845	21 702		1 206	95	1 301	23 003
Changes in cover														
Man-made changes														
Afforestation				58		58	53	5	58					58
Deforestation			- 1	- 60		- 61	- 56	- 5	- 61					- 61
Natural events														
Natural expansion														
Degradation														
Change in classifications														
Economic decisions			- 104			- 104	- 95	- 9	- 104		95	9	104	0
Catastrophic events														
Closing area 31.12.1995			375	21 220	0	21 595	19 759	1 836	21 595		1 301	104	1 405	23 000

Source: Statistics Finland.

3. Physical accounts for timber

Classification of timber

8.176 Since the characteristics of forests have been used to classify wooded land, it is not surprising that the classification for timber is similar. The accounts focus on timber in forests available for wood supply. However, accounts for timber in strictly protected areas and in areas under economic restrictions are also very important and should be shown separately, since the possibility for changes in economic restrictions may affect the availability for wood supply. It is assumed here that only non-cultivated forests occur in strictly protected areas or in areas under economic restrictions.

8.177 TBFRA-2000 (United Nations, Economic Commission for Europe, and Food and Agriculture Organization of the United Nations, 2000) introduces a specific category for **trees outside the forest**, that is, trees on land other than wooded land. This category includes:

(a) Trees on land that meets the definition of forested land or of other wooded land except that the area is less than 0.5 hectares and the width is less than 20 metres;

(b) Scattered trees in permanent meadows and pastures;

(c) Permanent tree crops such as fruit tree orchards and coconut palm plantations;

(d) Trees in parks and gardens, around buildings, in hedgerows and in a line along streets, roads, rivers, streams and canals;

(e) Trees in shelter belts and windbreaks of less than 20 metres in width and 0.5 hectares in area.

8.178 This is not an important category for countries with large forest resources, but may be of importance in less densely forested countries. This category can be useful when consolidating data on timber stocks and removals from various sources, especially when trees in this category provide an important source of wood.

Timber accounting concepts

8.179 TBFRA-2000 offers a set of normalized definitions which are presented below. Country-specific definitions (for example, those used in forest inventories) may differ from the TBFRA-2000 definitions.

> **Standing volume:** The volume of standing trees, living or dead, above stump measured over bark to the top. Includes all trees regardless of diameter, tops of stems, large branches and dead trees lying on the ground that can still be used for fibre or fuel. Excludes small branches, twigs and foliage.
>
> **Growing stock:** The living component of the standing volume.
>
> **Gross annual increment:** The average annual volume of increment over the reference period of all trees, with no minimum diameter. Gross annual increment is thus equivalent to natural growth in a year.
>
> **Net annual increment:** The average annual volume over the reference period of gross increment less natural losses.
>
> **Natural losses:** The average annual losses to the growing stock during the reference period due to mortality from other causes than cutting by man, for example, natural mortality, disease, insect attack, fire, wind throw or other physical damages.
>
> **Annual fellings**: The average annual standing volume of all trees, living or dead, measured over bark (with no minimum diameter) that are felled during the reference period, including the volume of trees or parts of trees that are not removed from forested land, other wooded land and other felling sites. Includes silvicultural and pre-commercial thinnings and cleanings left in the forest, and natural losses that are not recovered.
>
> **Annual removals**: The average annual volume of those fellings that are removed from forested land, other wooded land and other felling sites during the reference period. Includes removals during the reference period of trees felled during an earlier period and removal of trees killed or damaged by natural causes (natural losses), for example, fire, storms, insects and diseases.

8.180 It should be noted that TBFRA-2000 has introduced an important change in the concept of (standing) volume, which it defines as measured without a minimum diameter. Previous definitions had defined standing volume as measured with a minimum diameter of seven centimetres at breast height.

Timber accounting practices

8.181 Changes in stocks of timber are due to:

(a) Natural growth of timber (gross annual increment);

(b) Fellings of timber;

(c) Natural losses, including catastrophic natural events;

(d) Changes in land classification;

(e) Reassessment of stock.

8.182 A **forest account for timber** in physical terms shows the opening and closing stocks of standing timber and the changes occurring between the beginning and the end of the accounting period. Although TBFRA-2000 does not provide any standard forest balance, according to the definitions, the change in stocks of standing timber between the beginning and the end of the accounting period is equal to gross increment less removals less any losses not accounted for in removals. Any changes in use or status should also be included.

8.183 For **material flow accounting** and **physical input-output tables,** annual removals of timber should be separated from felled timber not removed from the forest. Further, the volume of fellings that is removed from the forest should be divided into saw logs, pulp wood and fuelwood by tree species or main group of tree species of most economic importance.

8.184 The **sustainable yield** of renewable natural resources is traditionally defined as the extraction level of the resource that does not exceed the growth. However, this definition is too restrictive in many cases. For a given stock of a biological resource, in principle there can be many definitions of sustainable yields. Forests have several functions besides logging (such as habitat protection, recreation and biodiversity) and the sustainable yield has to be defined on the basis of a particular objective. Ideally, the sustainable yield should be determined by forest experts on the basis of modelling; but if no such information is available natural growth can be used as a proxy. With respect to timber, the sustainable yield refers to fellings whose level does not exceed growth of timber during the accounting period (in other words, net growth is positive or zero). The sustainable yield refers to total fellings and not only to timber removed for own consumption and use. Another way of putting this is to say that if the closing stock is at least as high as the opening stock, the yield for the accounting period is sustainable. During transitional periods (for example, after afforestation), the sustainable yield will differ from natural growth. The same may apply during a previously virgin forest's transition to being regularly managed.

8.185 It should be noted here that even when the difference between the opening and the closing stock in the physical account is positive or zero, depletion may still occur in monetary units as a result, for instance, of changes in the age structure of the standing timber.

An example of physical accounts for timber

8.186 Table 8.14 shows the standing timber corresponding to the forested land in Table 8.13.

Table 8.14. Asset account for standing timber (volume)

Millions of solid cubic metres, over seven centimetres in diameter, over bark

	Forest land	***Available for wood supply***	Natural forests	Semi-natural forests	Plantations	***Total***	Conifers	Broadleaved	***Total***	***Not available for wood supply***	Conifers	Broadleaved	***Total***	**Total forest land**
Opening stock 31.12.1990			40.1	1 784.3	0.0	1 824.4	1 501.5	322.9	1 824.4		57.3	5.3	62.6	1 887.0
Natural growth			7.9	352.2		360.1	279.8	80.3	360.1		8.1	2.3	10.4	370.5
Fellings							- 215.2	- 55.9	- 271.1					- 271.1
Harvested timber							- 201.5	- 45.2	- 246.7					- 246.7
Saw logs							- 102.0	- 5.9	- 107.9					- 107.9
Pulp wood							- 91.7	- 23.5	- 115.2					- 115.2
Fuelwood							- 7.8	- 15.8	- 23.6					- 23.6
Timber left in the forest							- 13.7	- 10.7	- 24.4					- 24.4
Felling residuals							- 13.7	- 10.7	- 24.4					- 24.4
Other timber														
Changes in classification							- 7.9	- 1.7	- 9.6		7.9	1.7	9.6	0.0
Closing stocks 31.12.1995							1 558.2	345.6	1 903.8		73.3	9.3	82.6	1 986.4

Source: Statistics Finland.

4. Monetary accounts for forested land and timber

8.187 The general principles of valuing natural resources as they apply to timber and forested land are explained in section E of chapter VII. The present subsection elaborates these guidelines in the context of the numerical example given below.

Timber

Monetary asset accounts for timber

8.188 The monetary asset account for timber consists of the opening stock, flows, changes in classification, revaluations and closing stock. Flows include net natural growth, timber removals, timber left in the forests and catastrophic losses. Revaluation records the change in value due to changes in prices of standing timber between the beginning and the end of the period.

8.189 A disaggregation of the timber asset account between natural (non-cultivated) and plantation (cultivated) forests is needed, since in the SNA, natural growth in cultivated forests is treated as production. In natural forests only harvested timber is counted as production. However, in many countries the current SNA practice – a holdover from the 1968 SNA – is to count only harvested timber as production in all forests. As explained above, depending on national practices, it may be desirable to distinguish semi-natural forests also.

Valuing timber stocks and flows

8.190 As noted in the subsection on accounts in physical terms, changes in physical stock levels of timber are caused by the net annual increment (natural growth less natural losses), fellings, the effect of catastrophic natural events and changes in land classification. For monetary accounts, the same elements appear, as well as changes due to other classification changes such as those restricting use and any holding gains and losses.

8.191 If the closing stock level is calculated as the sum of flows and the opening stock level, the valuation methods used for the opening stock and flows should be closely compatible. If not, one of the terms explaining the reconciliation between opening and closing stock levels will absorb any inconsistency in valuation methods used.

8.192 For timber **stocks**, the consumption value and stumpage value methods are applicable, as well as the net present value method.

8.193 **Natural growth** can be valued by any of these methods also. The method chosen should be consistent with the valuation method used for the stock.

8.194 It should be noted that because of forest legislation and/or environmental and economic reasons the total amount of natural growth may not be available for utilization. There is then a question whether timber that cannot be harvested should be given the same value as harvestable timber, a zero economic value or some intermediate value. If the amount of non-recoverable timber is very significant, the restrictions on felling may be sufficient to increase the price of the amount that can be felled. In this case, since an overstatement will be made if the elevated price is applied to both actual removals and growth left in situ, a lower value should be used. If a value lower than the harvestable value is used and if the share of the non-recoverable timber is significant, the average value of natural growth will be lower than the average value of the recoverable timber. It is likely to be reasonable to assume that the level of unrecovered timber in cultivated forests is minimal.

8.195 If the restrictions on felling are not considered to have a significant effect on the price of timber available, this value should be applied to the growth left in situ also. Such a choice will apply to forests where a wood supply is available but where protection (IUCN categories III-V) decreases felling potentials.

8.196 **Fellings** (harvested timber) consist of removals and felling residuals left in the forest.

8.197 The value of **removals** is always given by the stumpage value of the timber removed from the forest. When the stumpage prices are known, the removals (described as assortments of wood in the rough) must be translated into the corresponding volumes of standing timber (described by age/diameter) and then valued by the stumpage prices. When the stumpage prices are not available, harvesting costs must be deducted from the value of the wood in the rough. It is worth noting that, in some circumstances, stumpage values may be set artificially low for policy reasons, for example, to encourage employment in remote areas.

8.198 ***Felling residuals*** left in the forest may have a zero value or, if they are gathered for own use, may have a value somewhat lower than the value of the harvested timber.

8.199 The value of **catastrophic losses** is given by the difference between the value of the stock of timber just before the catastrophic event and its value immediately after.

8.200 When the catastrophic event does not destroy the wood, it is necessary to take into account the value of the wood that will be salvaged. This value is a consumption value, although owing to problems of quality and excess supply the prices to be used may be lower than "normal" prices. There may also be supplementary costs for the recovery and the storage of the felled timber, the clearance of the forest and so on. The stumpage value of the salvaged timber has to be accounted for in the value of the stock for the period until its removal from the forest, which, in some cases, may take a number of years.

8.201 Other changes that affect the value of stocks of standing timber as a resource for the logging industry are **changes in use or status**, occurring, for example, when forested land is protected and logging is prohibited. In this case, the value of the standing timber is reduced to zero.

8.202 The value of **holding gains and losses** results from the change in the prices of timber, forestry costs and rate of discount between opening and closing balance sheets. When the net present value method is used, the value of the stock of standing timber also depends upon the assumptions made concerning the pattern of removals. These assumptions may differ from what obtains in actual removals. In this case, the impact of these differences on the value of the stock has to be analysed and classified as an “other change in volume”.

Forest accounts by institutional sector

8.203 It is desirable to have asset accounts for timber disaggregated by institutional sector (for example, government and private enterprises) but this is possible only if the basic data for these sectors are available. Forest land area by ownership category may often be available, but timber volumes, changes therein and actual market prices by the same categories can be derived only from area and statistics on timber resources. At least the main elements of monetary timber balances (opening stock, fellings, closing stock) should be presented (as estimates of shares of the totals, if necessary) by ownership (private and public).

An example of a monetary account for timber

8.204 Table 8.15 gives an example of a monetary account for timber available for wood supply. The estimates are made by applying stumpage prices to the physical data for stocks and flows of timber.

5. Accounts for forest products

8.205 As well as the fellings harvested, there are other non-wood products that should be estimated for a full accounting of the environmental yield of a forest. Non-wood products for own consumption and industrial uses are grouped as:

(a) Food (game, berries, fruits, mushrooms, nuts, palm oil, honey etc.);

(b) Medicines;

(c) Fodder/forage for animal breeding;

(d) Industrial extracts (cork, rubber, gum, tar, chemicals);

(e) Forest animals as agricultural products (wild boar, reindeer etc.).

Table 8.15. Asset account for standing timber (value)

Millions of Finnish markkaa

	Conifers	Broadleaved	*Total*
Opening stocks 31.12.1991	242 187	32 112	274 299
Natural growth	36 343	6 811	43 154
Fellings	-28 960	-4 342	-33 302
Harvested timber	-28 182	-3 785	-31 967
Saw logs	-19 708	-1 342	-21 050
Pulp wood	-8 130	-1 831	-9 961
Fuelwood	- 344	- 612	- 956
Timber left in the forest	- 778	- 557	-1 335
Felling residuals	- 778	- 557	-1 335
Other timber			0
Changes in classification	-1 015	- 141	-1 156
Revaluation of stocks	-24 351	- 518	-24 869
Closing stocks 31.12.1995	224 204	33 922	258 126

Source: Statistics Finland.

8.206 Flows of non-wood products are expressed in kilograms extracted for own consumption and industrial use (cork may be measured in cubic metres). If possible, a separation should be made between products coming from forests that are available for wood supply and those that are not. Not all products listed above will exist in all countries or in sufficient quantity to make quantification either desirable or possible.

8.207 Non-wood products are linked to material flow accounts, physical input-output tables and physical accounts showing volumes of goods for own consumption and sent to market. The values of products are separated into those for own consumption and those used by industries (classified by ISIC or by NACE).

Valuation of non-wood products

8.208 The volumes of non-wood products are converted from physical to monetary terms using average market prices for the products concerned. These values are imputed for non-wood products for own consumption as well as for products for sale. Market values include the costs of collection hence timber and non-wood product values will not be fully consistent because the value of timber is calculated directly as the product of the stumpage price and the volume of timber harvested without allowing for logging costs.

An example of an account for forest products

8.209 Table 8.16 sets out illustrative figures for timber and non-wood products. In this case, the value of the non-wood products is approximately 10 per cent of the value of timber extracted.

Table 8.16. Volume and value of all forest products

	Volume in thousands of tons	Value at current prices, 1991-1995 (Millions of Finnish markkaa) Branches of industry (ISIC)					
	Total 1991-1995	Agriculture	Hunting as branch of industry	Forestry and logging	Charcoal production	Others, including own consumption	Total
Timber	204 000			30 842		958	31 800
Conifers	161 000			27 689		345	28 034
Broadleaves	43 000			3 153		613	3 766
Others							
Industrial extracts							
Cork							
Rubber							
Tar							
Chemicals							
Other							
Forest animals (reindeer)	17	454					454
Food							
Fruits							
Meat from hunting	40					1 293	1 293
Berries and mushrooms	130	360				960	1 320
Nuts							
Palm oil							
Honey							
Others							
Medicines							
Fodder/forage	2	46					46
Total		860		30 842		3 211	34 913

Source: Statistics Finland.

6. Expenditures on forest management and protection

8.210 The ISIC industry forestry and logging includes silviculture, forest improvement and logging activities. This should be included in the data in the SNA for forestry and logging. Costs of environmentally sound forestry and logging methods that aim, for example, at improving biodiversity and ensuring the possibility of multiple forest uses should be separated from conventional forest management and recorded as a subcategory of expenditures.

8.211 Expenditures on environmental protection are described in detail in chapter V. Expenditures on forest protection include conservation of protected forests (according to IUCN categories) and costs of environmental protection activities such as the prevention of forest degradation and pollution, and the restoration and reparation of forests. Restoration and reparation costs should be separated from the cost of forestry and logging purely for purposes of wood production. Actual expenditures may represent new investments or maintenance costs. Costs should be split not only by industry but also between the public and private sectors.

8.212 Table 8.17 illustrates expenditures on forest management and protection.

Table 8.17. Expenditure on forest management and protection

Millions of Finnish markkaa, 1991-1995

	Forestry and logging[a]							
	Private	Forest industry	State	Environmental protection services	Public administration, other public services	Other branches of industry	Total	*Of which public sector*
Forestry and logging								
Forest improvement and silviculture	4 845	415	564				5 824	564
Logging	3 557	6 256	2 014				11 827	2 014
Environmentally sound forestry and logging[b]	350	40	50				440	50
Forest protection	..	..	..					
Prevention								
Restoration								
Forest conservation					920		920	920
Total								

Source: Statistics Finland.

Note: Two dots (..) indicate that data are unavailable.

[a] Included in the forestry and logging sector in the SNA.

[b] Estimated stumpage values lost because of the use of environmentally preferable methods in loggings (for example, leaving standing trees in the logged area for biodiversity protection).

7. Supplementary tables

8.213 The present subsection gives a brief overview of some of the supplementary tables whose compilation may be useful when wooded land is being studied in depth. The topics covered are:

Ecofloristic zones

Protection status (protected (IUCN)/non-protected)

Carbon binding

Age structure of forests

Forest health

Biodiversity and ecosystems

Non-wood services

Ecofloristic zones

8.214 Ecofloristic zones are structured as:

Tropical forests

Dry (Mediterranean-type) forests

Temperate forests

Boreal forests

8.215 Typically, only one or two main types of ecofloristic zones occur in a single country, so national disaggregation of a single ecofloristic zone to subcategories can be carried out on the basis of information needs on ecological and forest quality, climate condition and geographical aspects.

8.216 **Tropical forests** can be subdivided into:

(a) Rainforests: lowlands with a pluvial regime (more than 2,000 mm/year of rain);

(b) Moist deciduous forests: lowlands with a moist regime (1,000-2,000 mm/year of rain with a short dry season (less than three – four months));

(c) Dry deciduous forests: lowlands with a moist regime (1,000-2,000 mm/year of rain with a long dry season (more than six – seven months));

(d) Very dry deciduous forests: lowlands with a tropical dry regime (500-1,000 mm/year);

(e) Desert zone: lowlands with less than 500 mm/year of rain;

(f) Hill and montane zone: forests within the altitude range of 1,000-3,000 metres;

(g) Other tropical and subtropical forests.

8.217 **Dry (Mediterranean-type) forests** include forested land characterized by evergreen and sclerophyllous tree species associated with dry, hot summers.

8.218 **Temperate forests** include forested land with predominantly broadleaved, mixed and, on certain sites (such as higher elevations), coniferous tree species associated with mild or cool climate conditions and precipitation around the year.

8.219 **Boreal forests** include forested land in the northern latitudes with predominantly coniferous tree species associated with harsh winter conditions and a short growing season.

Protection status

8.220 IUCN associates the **protection status** for forested land with five categories as follows:

I. Scientific reserves and strict nature reserves

II. National and provincial parks

III. Natural monuments and natural landmarks containing unique geologic formations, special animals or plants or unusual habitats

IV. Managed nature reserves and wildlife sanctuaries protected for specific purposes (for example, conservation of significant plant or animal species)

V. Protected landscapes and seascapes, which may be entirely natural or include cultural landscapes (for example, agricultural areas)

8.221 Protection according to IUCN classification does not match perfectly the division of forested land into available/not available for wood production. Fully (strictly) protected areas are maintained in a natural state and are closed for extractive uses. These include those classified to IUCN categories I and II. For areas classified to category I, public access to the area is limited; areas classified in category II are open for recreation and study. Some extractive uses are allowed on lands classified to categories IV and V (not strictly protected areas). It may sometimes be unclear whether category III encompasses strictly protected areas or areas where some extractive use of timber is allowed. The recommendation here is to include in category III not strictly protected areas, since the possibility exists that management for specific uses includes felling and monetary output of timber.

8.222 Timber in forests available for wood supply that are not strictly protected is not available for forestry and logging activities to the same extent as in forests that are not protected at all. This may affect the monetary value of the timber in such forests (as explained above in the discussion of the valuation of timber).

8.223 Table 8.18 and Table 8.19 show the stock levels and changes of timber and forested land according to protection status. In the case of these data for Finland, there is only a slight difference between the two tables in respect of the information conveyed; the proportion of standing timber that is protected is slightly greater than that of protected forested land.

Table 8.18. Asset account for standing timber according to protection status

Millions of cubic metres

	Opening stocks 31.12.1990	Growth of timber	Fellings	Catastrophic events	Changes in land classification	Reassess-ments of stocks	Closing stocks 31.12.1995
Forest land							
Available for wood supply							
Not protected	1 756.3	347.1	- 261.1		- 12.4		1 829.9
Not strictly protected	68.1	13.0	- 10.0		2.8		73.9
Not available for wood supply							
Strictly protected	62.6	10.4	0.0		9.6		82.6
Total	1 887.0	370.5	- 271.1		0.0		1 986.4

Source: Statistics Finland.

Table 8.19. Asset account for forested land according to protection status

Thousands of hectares

	Opening stocks 31.12.1990	Afforestation	Deforestation	Natural events	Changes in classification	Reassess-ments of stocks	Closing stocks 31.12.1995
Forest land							
Available for wood supply							
Not protected	20 532	58	- 58		- 134		20 398
Not strictly protected	1 170		- 3		30		1 197
Not available for wood supply							
Strictly protected	1 301				104		1 405
Total	23 003	58	- 61		0		23 000

Source: Statistics Finland.

Carbon binding

8.224 The amount of carbon bound in wood and tree biomass can be derived from volumes, growth and fellings of standing timber using average coefficients for biomass by tree species from national sources, FAO or the Secretariat of United Nations Framework Convention on Climate Change (United Nations, 1994). Carbon binding is related to the non-wood services of forests, specifically protection services concerning climate.

8.225 The biomass of trees is divided into above-ground biomass of stem wood (including bark) and other above-ground tree biomass (branches, leaves, needles etc.). The above-ground biomass of woody plants is the biomass of bushes, shrubs and twigs (including foliage). Carbon balances derived from stem wood and other above-ground tree biomass are compiled both for forests available and not-available for wood supply, and for main groups of tree species. Balances can be expanded to total carbon stored in the forest ecosystem by adding the carbon bound in below-ground vegetation and forest soils.

8.226 The average coefficients used in Finland to convert the data in Table 8.14 showing timber by cubic metres over bark to tons of carbon are 0.3091 for pine, 0.3715 for spruce and 0.4152 for broadleaved species. Below-ground biomass is taken to be 23 per cent of the above-ground estimates. These conversions result in the figures shown in Table 8.20.

Table 8.20. Carbon binding and the accumulation of tree biomass

Millions of tons of carbon

	Forest land								
	Available for wood supply			***Not available for wood supply***					
	Conifers	Broadleaved	***Total***	Conifers	Broadleaved	***Total***	**Total above-ground tree biomass**	**Total below-ground tree biomass**	**Total tree biomass**
Opening stock 31.12.1990	511.0	134.1	645.0	19.5	2.2	21.7	666.7	199	866
Natural growth	95.2	33.3	128.6	2.8	1.0	3.7	132.3		
Fellings	- 73.2	- 23.2	- 96.4				- 96.4		
Changes in land classification	- 2.7	- 0.7	- 3.4	2.7	0.7	3.4	0.0		
Change in carbon	19.3	9.4	28.7	5.5	1.7	7.1	35.8	11	47
Closing stocks 31.12.1995	530.2	143.5	673.7	25.0	3.9	28.8	702.6	210	913

Source: Statistics Finland.

Forest age structure

8.227 The age structure of a forest is often expressed in terms of the areas of the forest consisting mainly of trees of the same age (in other words, by age class) or by proportions of trees in different age classes. The age-class division used is dependent on the ages of trees of different species. For forest accounting purposes, it is useful to have the age structure expressed in terms of timber volumes. This may be derived by combining data on the number of trees with the average volume of timber for a tree of a given age. Since the volume of a mature tree is much larger than that of a young tree, the distribution of timber volume may be very different from the distribution of number of trees.

8.228 Overmaturity is a combination of biological and economic characteristics (age of trees compared with average rotation period by tree species, soil productivity and climate conditions). Overmature forests, which are defined as forests of age higher than the length of the rotation period, can be recorded as natural forests if no silvicultural and/or logging activities have taken place in those forests during the previous 30 years.

8.229 Table 8.21 provides an example of the age profile of Finnish forests. The data are derived from a single forest census and show the proportion of the total area of forested land in each of the age classes specified. It is of interest to be able to compare such profiles for different periods in order to ascertain whether and how the average age of the forest is changing.

Table 8.21. Age profile of a Finnish forest

Percentage distribution of total area (age in years)

Treeless	Up to 20	21-40	41-60	61-80	81-100	101-120	121-140	Over 140
1.5	15.4	18.0	16.8	16.0	12.0	6.9	4.3	9.2

Source: Statistics Finland.

8.230 Table 8.22 gives similar information in volume terms and by dominant species.

Table 8.22 Age and timber volumes in a Finnish forest, by dominant species

Solid cubic metres over bark per hectare (age in years)

	Up to 20	21-40	41-60	61-80	81-100	101-120	121-140	Over 140
Pine	14	63	101	133	155	153	141	140
Spruce	24	80	171	198	208	211	192	185
Broadleaved	19	81	123	167	174	182	208	191

Source: Statistics Finland.

Forest health

8.231 Forest health is affected by both natural and human factors. A correlation of forest health with a single factor such as air pollution is seldom very clear-cut. Defoliation is the most commonly used factor in describing forest health. It is expressed as the quantity or proportion of trees whose crown is more than 25 per cent defoliated. Other symptoms of forest damage that reduce stand quality are the quantity and proportion of dead, fallen and broken trees, decayed trees, stem defects, top damage, discoloration and multiple symptoms. It should be noted, however, that the presence of dead and decayed trees is also often seen as a forest characteristic that improves biodiversity.

8.232 Defoliation and other elements of forest health are measurable for forest area in either hectares or percentages, but data on them do not directly relate to volumes of standing timber. Defoliation data should be presented by authenticity/naturalness classes and by predominant tree species or groups of tree species.

8.233 Table 8.23 shows the state of defoliation for different types of tree species. It covers only timber growing in mineral soil and not in peat land.

Table 8.23. Degree of defoliation by tree species

Percentage

	Total forest land: mineral soil sites		
	Pine	Spruce	Broadleaves
1990	6.9	34.2	13.0
1995	4.8	27.8	11.0

Source: Statistics Finland.

Biodiversity

8.234 Biodiversity is a very broad concept whose importance varies from one country to another. Factors in forest biodiversity are, for example, forest soil types (mineral, peat, wetland etc.); forest altitude (lowlands, ridges, hills, mountains etc.); proximity to water sources such as inland waters, groundwater, estuaries and archipelagos; and proximity to agricultural areas. The suitability of a forest for multiple uses (for example, supply of timber and non-timber forest products) is also closely connected to biodiversity. Describing biodiversity and its development in semi-natural managed forests by ecofloristic zones and by predominant tree species is thus very important in forest accounting.

8.235 In forest accounting, biodiversity focuses on diversity of forest ecosystems and diversity of forest-dwelling species. If, owing to changes in climate say, there is an increase in species not previously growing locally, it is useful to document this. Some elements of biodiversity are included in the accounting of the qualitative and quantitative aspects of forests, including ecofloristic zones, protection status, and proportions of tree species in total standing timber and in forested land area. Authenticity/naturalness of forests is of importance because the state of and changes in biodiversity are often different in natural forests, semi-natural managed forests and plantations. The biodiversity of plantations is usually lower than that of other forest areas and the introduction of foreign tree species involves higher ecological and economic risks than the planting of traditional species. In countries where plantations are important, it can be useful to describe the biodiversity of these areas separately.

8.236 The number of endangered species of flora and fauna (that is, those with a high risk of extinction in the near future) is a useful biodiversity measure for all forest types. The number of endangered species should, if possible, be further disaggregated by areas of predominant tree species, by ecofloristic zones, and by natural and semi-natural forests. Table 8.24 gives an example of such information on endangered species. There is a discontinuity in the information available for 1997 compared with earlier years.

Table 8.24. Endangered species

	Total number of known species		Number of endangered forest species		
	1985	1990	1985	1990	1997
Vascular plants	1 350	1 550	34	38	
Trees					8
Coniferous					
Broadleaved					
Others					
Flowers					35
Non-vascular plants	13 700	14 740	207	356	
Mosses					37
Macrofungi					
Algae					
Lichen					62
Vertebrates	372	373	17	15	
Mammals					7
Birds					13
Other					
Invertebrates	25 000	25 500	200	318	
Butterflies					47
Others					

Source: Statistics Finland.

8. Compatibility with international data sources

8.237 The structure, definitions and classifications of the asset accounts for forests in the SEEA framework are compatible as far as possible with international forest and forestry product statistics.

8.238 Statistics compiled by FAO cover tropical, temperate and boreal forests worldwide. FAO has undertaken periodic forest assessments since 1946. The latest assessments have been compiled for 1990 and 2000. The framework for the 2000 assessment is an update of the previous version. In the FAO assessment, original national data are reorganized in order to obtain a common classification, format and reference date. The FAO framework emphasizes the sort of accounts discussed above but also includes a number of supplementary tables, many of which have an ecological orientation.

8.239 The FAO forest assessments are based on national forest inventories, on survey data or on estimates made by FAO. The length of national forest inventory cycles is 1-15 years and the number and frequency of inventories and surveys vary between countries. Continuous annual forest inventories or surveys are hardly ever undertaken. Opening and closing stocks or balance sheets are available for the reference year (or period when forest inventories are carried out on a rotating basis) but the time-span between opening and closing figures usually varies between 5 and 40 years.

8.240 The Intergovernmental Panel on Climate Change (IPCC) was, at the time this Handbook was being written, in the process of preparing guidelines for the preparation of national communications on annual greenhouse gas emission reports. The guidelines contain proposed definitions and a classification concerning forest assets. The SEEA accounts presented here are compatible, although not fully harmonized, with the IPCC guidelines. National reporting to meet IPCC requirements and the separate compilation of forest assets accounts should serve as complementary data sources. It may prove necessary to update the methodology for asset accounting for forests presented here so as to take account of the final version of the IPCC guidelines.

8.241 A considerable amount of data on physical and monetary flows related to forests is available on an annual basis or for other periods shorter than that typical in national forest inventories or surveys. This makes it possible to build asset accounts according to the general structure based on "opening balance sheet, changes in balance sheet, closing balance sheet". Even so, the construction of physical forest asset accounts, especially for opening and closing stocks and balance sheets, is seldom possible for one-year accounting periods at an adequate level of statistical reliability, though annual asset accounts may be estimated using models.

E. Accounts for aquatic resources

1. Introduction

8.242 The present section provides an overview of the issues involved in compiling accounts for aquatic resources. At the time of the writing of this Handbook, a new handbook to be called the *System of Integrated Environmental and Economic Accounting for Fisheries* (SEEAF) was in preparation. This new Handbook, whose joint publishers are the United Nations and FAO, deals at much greater length with the subject of accounting for aquatic resources. There is discussion of the use of these accounts in chapter XI.

8.243 The economy interacts with the whole aquatic ecosystem in several ways. Fish stocks are subject to exploitation for commercial as well as recreational and subsistence fishing activities. The abundance and health of wild fish stocks in inland and marine waters are also increasingly affected by water pollution and by the degradation of fish habitats through landfills, damming and diversion of rivers, clearance of mangroves, sedimentation, coral mining, deforestation in the hinterland and other activities. The dual impacts of excessive exploitation levels and habitat degradation result in the loss, or reduction, of the economic value of the goods and services provided by the aquatic ecosystems and a loss of biodiversity and genetic resources.

8.244 In most parts of the world, fishing capacity has reached a level where unrestricted fishing will result in overexploitation and lead to smaller catches and economic benefits than would be possible if the exploitation was managed. In extreme cases, there is the risk of extinction of some fish stocks with attendant impacts on the aquatic ecosystem. Fisheries management depends upon available information to maximize economic benefits from the use of renewable aquatic resources. In many cases, this information is limited and its quality uncertain.

8.245 Accounting for aquatic resources is a means to improve the informational basis for fisheries management. In particular, it allows for:

(a) Identification of production, income, prices, trade in fish and fishery products for the fishing industry and all industries connected with the extraction and processing of fish;

(b) Assessment of the physical size of the most important aquatic resources, especially commercially exploited fish stocks and, in those cases where it is deemed realistic, estimation of the monetary value of these natural resources;

(c) Assessment of the cost of overexploitation and the benefits from efficient management of the aquatic resources exploited by the commercial fisheries;

(d) Analysis of the efficiency of the management of the natural resources in the past and analysis of possible costs and benefits from the exploitation of these natural resources in the future;

(e) Analysis of the effects of public policies on the fisheries sector (both general macroeconomic policies such as those involving taxes and interest rates, and policies aimed at the fishing sector such as subsidies);

(f) Assessment of fisheries management and habitat protection costs;

(g) Assessment of the value of aquatic resources shared with other countries.

2. Characteristics of the fishing industry

8.246 It is necessary to consider some special characteristics of the fishing industry, especially deep sea fishing, in order to make sensible decisions about how to compile useful accounts for aquatic resources. These characteristics cover where and under what legislative controls fishing is carried out and the attribution to country of the fishing boats.

Exclusive economic zones

8.247 Since the introduction of 200-mile exclusive economic zones (EEZ) in the 1970s and 1980s, most commercially important aquatic stocks have been under the jurisdiction of individual countries. Some wild stocks migrate between EEZs belonging to different countries. Some stocks migrate between EEZs of countries and international waters and some stocks live completely in international waters. Efforts have been made, within the United Nations framework, to ensure that the countries that exploit these so-called straddling stocks do so in an environmentally responsible manner.

8.248 The United Nations Convention on the Law of the Sea (see United Nations, 1997a), the Agreement for the Implementation of the Provision of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (United Nations, 1998, sect. I; see also A/CONF.164/37) and the Code of Conduct for Responsible Fisheries of the FAO (ibid., sect. III) created a legal framework for fisheries management. As a result, countries are able to set rules for fishing within their EEZs to prevent overfishing. International bodies have been set up and agreements on the management of fishing out of stocks in international waters have been reached to manage stocks, including those that straddle EEZs of different countries.

8.249 Methods for managing fisheries vary greatly. In some cases, fishing is largely free but the authorities make efforts to reduce the fixed capital devoted to fishing through purchase and then decommissioning of fishing vessels. In other cases, fishing effort is controlled by closing the fisheries during certain periods, establishing regulations on the types of fishing gear that may be used, or requiring a licence to fish. Management through catch quotas is common.

Fishing licences and quotas

8.250 In many countries, a fishing licence issued by government is required in order to practise either fresh water or marine fishing. If these licences apply for a period not exceeding one year, they are recorded in the SNA as taxes. For enterprises, they are treated as taxes on production; for private individuals fishing for pleasure, they are recorded as taxes on income. In some instances, a private individual or unit such as an angling club may own the fishing rights to a stretch of water and also charge a fee to would-be fishermen. This fee should be recorded as expenditure on recreational services.

8.251 An increasingly common approach to controlling marine fishing so as to prevent overfishing is to issue fishing quotas. These are usually issued by government (which is responsible for ensuring their enforcement as well) and may apply both to fishing within the waters of the country's EEZ and to fishing on the high seas. Quotas typically apply to a particular species of fish. Quotas may be given away free to certain designated persons (for example, people in locations where fishing is the main source of livelihood) or sold. A quota may be valid for one year only or for a longer period, sometimes for the lifetime of the quota-holder. It may or may not be tradable to third parties. Even if not tradable, in certain circumstances it may still be transferable, say, from one generation to the next.

8.252 If a quota can be sold by the holder to a third party, then the quota is recorded as an asset quite separately from the fish to which it relates. Quotas are classified as intangible non-produced assets in the SNA and are included as memorandum items in the SEEA asset classification.

8.253 One solution to the problem of country A's exhausting the stocks of country B is for country A to issue licences or quotas to country B for which a payment must be made. The licences or quotas are treated as described above. If a licence or quota is valid for more than a year, it is recorded as an intangible non-produced asset that is sold by country A to country B. Technically, therefore, country B does not pay country A for the fish it harvests per se but for the right to harvest them. Similar considerations hold for licences and quotas issued to residents: the holder of a long-term licence has an asset technically distinct from the fish whose harvest the licence controls.

8.254 The value of the licence or quota should ideally be determined by the price it would fetch on the open market. When no such price is available, the value of the licence or quota should be set equal to the net present value of the resource rent of the amount of fish that can be caught under it.

8.255 In a perfectly functioning market (through the market in fishing licences and quotas may not be such a market for all sorts of reasons, including lack of knowledge and of accessibility to the market, government social policy etc.), the value of the licence or quota would be equal to the net present value of the resource rent of the fish covered by the licence/quota. If the fish are to be harvested over a period of years, the value of the licence should be equal to the net present value of the resource rent from fishing over the period for which the license/quota is valid.

8.256 Whether or not a monetary valuation can be placed on fishing licences and quotas, it is useful to have information available on their existence and the proportion of various fish stocks covered by them.

Harvesting fish and the production boundary

8.257 The production boundary of the SNA includes all activities carried out under the responsibility, control and management of a resident institutional unit in which labour and assets are used to transform inputs of goods and services into outputs of other goods and services. In the case of fisheries, the growth of fish in fish farms is treated as a process of production whether the fish are harvested or not. The fish harvested in the open seas or inland waterways by commercial or recreational fishing count as production regardless of whether they are sold in the market or used for own consumption. On the other hand, natural growth of fish stocks in the open seas or inland waterways is not counted as production.

8.258 The output of an aquaculture establishment should be recorded as continuous production (that is, as a work in progress) by distributing the value of the slaughtered fish over time in proportion to the costs incurred in each period (1993 SNA, para. 6.96).

8.259 All capture fishing by residents should be recorded as production, including, data permitting, that part of the catch that fishermen use for feeding their families and the landed catches derived from recreational fishing even if not sold in the market. The catches used for own consumption should be valued at the prices for which they could be sold in the market excluding any taxes payable at the time of sale.

Capture fishing by non-residents

8.260 There is one issue involving capture fishing by non-residents where an exception is made by the SNA to its own rules on the boundary of production and one issue where the distinction between natural resources and products in the SEEA must be modified.

Non-resident vessels

8.261 Determining the residence of a fishing vessel is not always a straightforward matter. In earlier international manuals, it was assumed that the country of registration (that is, the flag under which the ship sailed) indicated the country of residence of the owner of the vessel and thus the country of residence to which the activity of the ship should be attributed. With the increasing practice of registering ships under flags of convenience, this assumption became unrealistic. The effect on the 1993 SNA and the corresponding balance-of-payments manual was that the determination of the attribution of residence to vessels and other movable equipment was changed.

8.262 The determining factor for residence of vessels is now the residence of the operator of the vessel, which, in many cases, will still coincide with both the country of registration of the vessel and the residence of the owner; however, neither of these considerations is germane to the decision on residence. If a vessel is chartered - whether with crew and equipment or without - to a resident of country A, it is considered to operate from country A; and for fishing vessels, the catch is the production of country A. If the operator of the vessel, even though personally resident elsewhere, is licensed and recognized as such by the tax authorities of country A, then the vessel is regarded as being operated by a resident and again the catch is the production of country A. On the other hand, if a fishing ship belonging to a resident of country A is chartered to a resident of country B, the catch is considered part of the production of country B and not of country A. The rental payment to the owner of the ship will be part of the service income of country A but not part of the fishing account.

8.263 Note that the determination of the residence of the operator of the fishing vessel has no relation to where the fish is caught or landed. This introduces an important difference in coverage between economic production and the physical removal of fish from national waters. In fact, it is necessary to consider a two-way classification, as in Table 8.25. Total economic production is the sum of the two entries marked X and Y. Total extraction from national waters is the sum of X and Z. The fourth entry, covering fish caught by non-residents outside national waters is not relevant to the accounts for country A.

Table 8.25. Fish catch, by residence of operator and catch location

	Fish in national waters	Fish outside national waters	Total
Vessel operated by residents	X	Y	Total economic production
Vessel operated by non-residents	Z		
Total	Total extraction from national waters		

Illegal fishing

8.264 If a resident fishes beyond the scope of his licence, he is fishing illegally. Nonetheless, the SNA requires that this harvest still be recorded as production with an income accruing to the fisherman, even though he is acting illegally. The application of the rules to non-resident vessels described above, though, implies that there will be no fishing by non-residents recorded as production above the level authorized by licence. Nevertheless, there are still physical removals of fish and these should, in principle, be taken into account in the physical accounts.

Products and natural resources

8.265 In chapter III, it was stated that exports of natural resources should always be recorded as routed via the economy. The extraction of iron ore, say, converts iron ore in the ground (a natural resource) into iron ore ready for transport (a product) and it is the product, not the natural resource, that may then be exported to another country. Fish is the exception to this general rule in consequence of the convention on the activity of non-resident fishing vessels. It is the only form of extraction of natural resources that can be envisaged as taking place by a non-resident unit. For all other extraction activities, a unit must be registered in the country where the natural resource is located.

3. Classification

8.266 Aquatic resources cover fish, shellfish and other aquatic resources such as sponges and seaweed, as well as aquatic mammals such as whales. Where no ambiguity can result, the term “fish” is often used as a loose synonym for “all aquatic resources”. The categorization of aquatic resources in the SEEA asset classification is as follows:

- EA. 143 Aquatic resources
  - EA. 1431 Cultivated
    - EA. 14311 For harvest
    - EA. 14312 For breeding
  - EA. 1432 Non-cultivated

8.267 A distinction between biological assets used for breeding and those used for harvest is made generally in both the SNA and the SEEA. It is applied in the case of fish, although fish kept for breeding purposes are uncommon.

8.268 The types of aquatic resources that are never drawn into the economic sphere are regarded as being covered within the category of aquatic ecosystems (EA.32: Aquatic ecosystems). They are assets in the SEEA but not in the SNA.

8.269 A pragmatic approach to the determination of the boundary between cultivated and non-cultivated assets is, in accordance with the FAO definition of aquaculture, to regard all farmed aquatic organisms as cultivated assets and all types of wild, enhanced and ranched fish stocks as non-cultivated assets. Capture fishing and aquaculture both take place in marine waters and freshwater. Capture production is much greater than the production of aquaculture both globally and in marine waters, but not in inland waters.

Aquaculture

8.270 Aquaculture is defined by FAO as follows:

> Aquaculture is the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms that are harvested by an individual or corporate body that has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms that are exploitable by the public as a common property resource, with or without appropriate licences, are the harvest of the fisheries".

8.271 From this definition, it is clear that aquaculture stocks correspond to cultivated resources. Globally, about 60 per cent of aquaculture is in inland waters and 40 per cent in marine waters.

8.272 Not all countries are heavily involved in aquaculture and for many it may be negligible. FAO publishes data for many countries showing a breakdown first between fish and shellfish and then by other aquatic organisms and finally by individual species at a very detailed level. About 90 per cent of the global total for fish and shellfish shown by FAO comes from Asia (mainly from China) as do virtually all of the other aquatic organisms.

Capture fisheries

8.273 Capture production of fish, as itemized by FAO, covers nominal catches of freshwater, brackish-water and marine species of fish, crustaceans, molluscs and other aquatic animals and plants, killed, caught, trapped or collected for all commercial, industrial, recreational and subsistence purposes. This itemization can be applied to stocks of fish as well. The nine divisions used by FAO are:

1. Freshwater fishes
2. Diadromous fishes
3. Marine fishes
4. Crustaceans
5. Molluscs
6. Whales, seals and other aquatic mammals
7. Miscellaneous aquatic animals
8. Miscellaneous aquatic animal products

9. Aquatic plants.

8.274 Diadromous fish are either those that normally live in salt water and spawn in freshwater (for example, salmon) or those that normally live in freshwater and spawn in the sea (for example, eels). Miscellaneous aquatic animal products encompass pearls, mother-of-pearl, shells, corals and sponges. Below these nine divisions, there are 50 groups covering 1,073 species.

4. Measuring the physical levels of stocks

Stock level

8.275 The SEEA and the SEEAF adopt a pragmatic approach whereby all fish stocks within the EEZ of a country are considered assets and therefore included in the asset boundary.

8.276 In addition to the fish stocks within the EEZ, the asset boundary may be expanded to also include those stock (migrating and straddling stocks and stocks that complete their life cycle in international waters) over whose exploitation control has been established and the access rights to which are shared among countries. In some cases, these international agreements specify explicitly the share of total catches that should be allocated to each country. When this is the case, each country's share of the stock of the common resource can be determined on the same basis.

8.277 In some cases, the fishing vessels of the countries concerned are not able to catch the full share that has been allocated to them, making it necessary to estimate the effective share in the resource from the actual share of the total catch rather than from the allowable share.

8.278 The share of catches allocated by international agreements to the countries sharing the resources is frequently amended, so that values of the additional stock to be added to the national wealth must be updated to reflect these changes.

Measuring stocks of wild fish

8.279 While the capture fishery is clearly associated with a flow of non-cultivated aquatic resources, measuring stock levels and determining what should be included in a nation's balance sheet remain affected by particular measurement issues.

8.280 Biologists define a stock of animals as a group of individuals from the same species that live in the same area and cooperate in breeding new offspring. In some cases, mating between members of different groups may be so infrequent that the overall dynamics of the groups is not influenced by their proximity. It may therefore be impractical from both a biological and a management point of view to regard them as belonging to the same stock. In other cases, different stocks of the same species spawning in separate grounds may mate in common feeding grounds. For management purposes, the stocks could be considered one stock.

8.281 Definitions of stocks for use in measuring stock sizes have to be adapted to the availability of data. For many species, biologists estimate the size of the stock in terms of the weight of those cohorts that appear in catches. This means that the total stock may be defined as the weight of all cohorts aged y years or older, where y is the age of the youngest fish in the catch. Too little is known about the cohorts that are younger than y to include them in statistics that are to be used for management purposes. The sexually mature part of the stock (the spawning stock) is frequently estimated, as it is believed that these estimates give an indication of the growth potential of the stock and the probability of a collapse.

8.282 Like all living creatures, wild fish form a part of a complicated ecological system where some fish are predators and others are prey. To be able to understand the dynamics of the biological system, estimate its productive potential, and avoid serious overfishing, it is important to gather information on stocks and catches of all species.

Virtual population analysis

8.283 Physical data on stocks are usually compiled by biologists who use different methods to estimate the size of the stocks. Virtual population analysis (VPA) is usually the most reliable method. It employs data on catches from different cohorts of the same stock, together with data on catch per unit effort. This method can be used only to estimate the size of the stock of those species that are relatively long-lived and where data on the proportions of the different cohorts in the catches are available. When this information is not available, the biologists rely on other models which relate the size of the stock to the availability of fish, estimated by catch per unit effort. These methods are often very imprecise, partly because it is very difficult to estimate the volume of effort in homogeneous units. The special case represented by the gathering of fish into schools makes it possible, with echo integrators (instruments that use sound waves to observe the fish in the water), to estimate the size of the total stock. Stocks of bigger aquatic animals like seals and whales can be estimated by direct enumeration of the number of animals in randomly sampled areas.

8.284 In most cases, biologists' estimates of the size of fish stocks are very imprecise. The variability in the recruitment to the stock (births), the effects of environmental factors affecting the growth of the individual fish, and the rate of natural death from accidents, sickness, old age and predators make it very difficult to estimate the productive potential of the fish stock. When the stock of fish declines, it may be difficult to determine whether this decline was caused by overfishing or by adverse environmental conditions.

8.285 On the basis of the data obtained with the VPA method, it is possible to obtain consistent estimates of the size of the stock at the beginning and at the end of the accounting period. The technique also permits estimates of all flows to be made, that is, catches, recruitment, increases in weight and losses because of sickness, accidents and predators. As more information becomes available about individual cohorts, it may be possible to improve estimates of stock levels made for earlier points in time.

8.286 When using the VPA method for estimating the size of fish stocks, biologists must make assumptions about the natural mortality of the stock. These assumptions may involve the size of some predator stock. Even so, biologists have rarely found it useful to present this physical information in an accounting format, because of doubts about the reliability of data, in particular the natural mortality rates.

5. An asset account for aquatic resources in physical terms

8.287 Ideally, an asset account in physical terms shows a time series of the stocks of all commercially important species (the species currently harvested), by geographical area or by local fishery if this is applicable. Additional information on related species (the prey of commercial species) could also be included, as could other relevant information on spawning habitat or environmental quality. All of these data are useful in assessing the viability of the economic activity. Geographical detail may be important when local or regional economies are dependent on the fisheries or in cases where the fisheries shift activity to different areas when new stocks are discovered or stocks in some areas are depleted.

8.288 In addition to stock levels, a physical account should show changes due to harvest, natural loss, growth (in volume) and recruitment (growth in numbers). Catch data are published by FAO and, in a number of countries, by the agencies that manage the fisheries. Data on stocks and changes are estimated by many fisheries agencies, but may not be published.

Aquaculture stocks

8.289 Increases come from cultivated recruitment and growth; planned decreases from harvesting. In addition, disease or a natural catastrophe may lead to unplanned decreases.

Freshwater aquatic resources

8.290 Increases come from natural recruitment and growth, and regular decreases from harvesting and natural death. Irregular decreases may be the result of water pollution, abnormal climatic conditions or natural disaster.

8.291 Harvesting of freshwater fish may be subject to controls but these usually entail general limitations on when and how harvesting may occur, or the issuing of licences for recreational fishing, rather than the sort of quotas that apply to marine fish.

Marine aquatic resources within a country's EEZ

8.292 The causes of increases and decreases are the same for marine fish as for freshwater fish but it is necessary to distinguish several classes of harvesting to take into account the impact on the production boundary, as discussed in subsection 2 above, namely, that fish may be caught:

(a) Without limit by nationals of the country;

(b) By nationals of the country of ownership under a general quota system;

(c) By nationals of the country of ownership under an individual quota system;

(d) By nationals of another country under an individual quota system;

(e) By nationals of the country beyond a quota allocation;

(f) Illegally by nationals of another country.

8.293 For different species, different classes of harvesting will apply. When preparing physical accounts, it is useful to record the amount of harvest for key species under whichever of these headings apply.

8.294 Obviously, the quantity of fish harvested either by nationals or by non-nationals beyond a quota cannot be known exactly yet even if a total of illegal fish taken can be estimated, judgement may need to be exercised to determine how much, if any, is attributable to nationals and non-nationals respectively. Nevertheless, if management of natural fish resources is seriously threatened by illegal fishing, it is important that estimates of this harvest be made, even if they are only approximate.

Measuring the harvest of fish

8.295 In physical terms, all fish harvested, whether by residents or by non-residents and whether legally or illegally, should be recorded. In practice, little firm evidence may be available on the harvest by non-residents, but, increasingly, quotas apply and it is possible to use these as approximations of the actual harvest.

8.296 It is important that all catches be duly recorded for estimations of the stock sizes and their productive potential. This means that there should be a recording not only of all landings, legal and illegal, by commercial and recreational fishermen, but also of all fish that are discarded at sea. The discarded fish should not be counted as part of production, but rather recorded as an other change in volume.

8.297 One other difficulty that may be encountered when compiling production accounts for fisheries concerns the separation of the harvesting from the processing activities, both with respect to factory vessels and in cases where companies whose primary activity is land-based fish processing (that is, manufacturing) also operate some fishing vessels. Although it is desirable to allocate the production to the relevant activity, this may be difficult in practice. If data are not available, it may occur that some on-board fish processing will have to be included in fishing and some fishing activities may have to be recorded under fish processing (United Nations and Food and Agriculture Organization of the United Nations, 1999).

8.298 There may be differences between volumes of catches and landings, and conversion is necessary to reconcile catches on a live-weight basis with landings on a landed-weight basis. Some countries may also refer to nominal catches on either a round, fresh basis; a round, whole basis; or an ex-water weight basis. Figure 8.4 shows schematically the relationships between these alternative concepts. For whales, seals and other aquatic mammals (FAO division 6), the term "catch" is preferred to "nominal catch" and the measurement is usually by number rather than by weight. For miscellaneous aquatic animal products (division 8), it is more usual to speak of production than of nominal catch.

8.299 An example of part of a physical account developed for Norway is shown in Table 8.26.

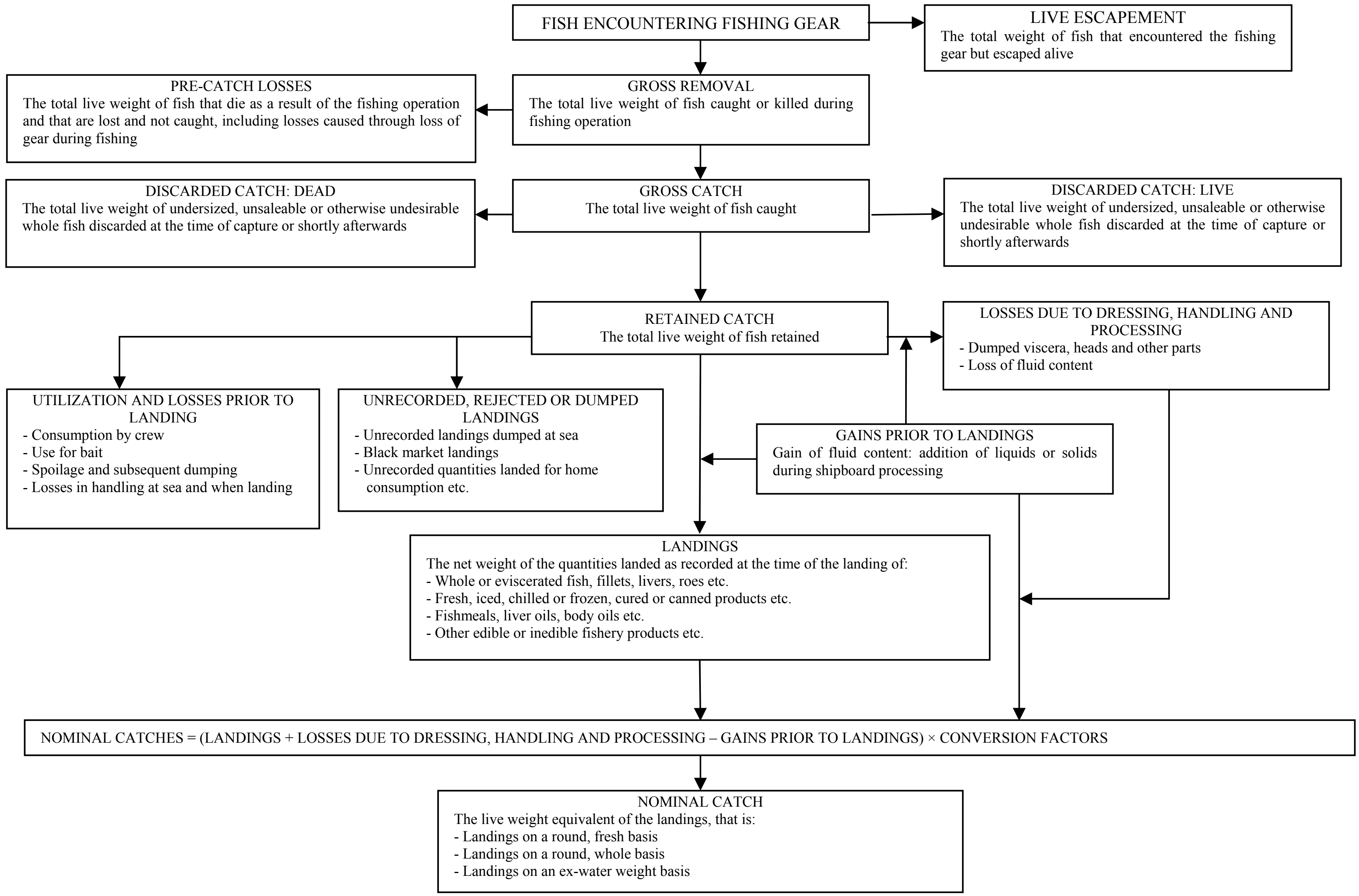
Table 8.26. Physical account for north Arctic cod (Norway)

Thousands of tons

Year	1993	1994	1995	1996
Opening stock	2 510	2 340	2 100	2 040
Catch (landings)	(532)	(746)	(740)	(722)
Other changes in volume (recruitment and natural mortality)	362	506	680	622
Closing stock	2 340	2 100	2 040	1 940

Source: International Council for the Exploration of the Sea (www.ices.dk).

Figure 8.4. Alternative catch concepts



6. Monetary asset accounts

8.300 The calculatation of the value of the stock of fish and of the harvest based either on an appropriation method linked to the value of the fishing quota or on the value of the resource rent of the harvest is discussed in detail in section VII.E.

8.301 A change in the value of an aquatic stock may be brought about by:

(a) Changes in physical size of the stock;

(b) Changes in technology that allow increases in the catch of fish for the same cost, thus increasing the resource rent;

(c) The effect of catastrophic losses;

(d) Changes in prices of the products (landings).

8.302 When it is not possible to identify reasons for changes in the size or value of stocks and to attribute the changes to natural causes or fishing activity, it will be possible to prepare only a minimal asset account. The physical accounts may consist of catch data for a number of species but without corresponding stock estimates for all of the species. It may not be possible to value the stocks of individual species, so that only a regional or national aggregate stock value will be produced.

8.303 Increasingly, though, estimates are available of stock levels for individual species, since this is the basis on which quotas are determined. Even when stock levels are not available, it is necessary to consider the causes of increases and decreases in the (unknown) levels in order to determine how to record these in monetary accounts. Ideally, recruitment ("births"), growth and natural loss could all be estimated and recorded separately. Owing to data limitations, this category is often available only as a composite "other changes" measured as the residual difference between the amount harvested and the change between opening and closing stock levels.

8.304 The interactions between different stocks add to the complications of estimating the value of the fish stocks. For example, the size of the catch, and therefore the value, of some prey stocks depends on the size of some predator stock. If the predator species has little commercial value, it may pay to catch the predator to increase the stock and thus eventually the catch of the valuable prey species. In this case, the value of the predator stock can become negative when the stock is big, as it then does more economic harm than good. Though important, the interactions between the different species are usually poorly understood and difficult to quantify.

8.305 Catastrophes are often taken to be synonymous with natural disasters such as floods, hurricanes and earthquakes. Biological resources, whether cultivated or not, are particularly vulnerable to disasters that can be traced back to human intervention such as loss of spawning habitat due to the damming or diversion of rivers or toxic spills into rivers or the sea. The impact of such man-made disasters should also be recorded in the accounts. The SNA records these in the other changes in assets account, but it could be argued that in the SEEA such decreases in the stock of biological resources should be recorded in the same way as harvesting, that is, as changes due to economic activities. Indeed, in some instances, it may not be possible to know how much of a decrease in stocks is due to overfishing and how much to detrimental environmental impacts caused by production processes. It is therefore suggested that in an account for aquatic resources, separate estimates for such impacts should be made, if at all possible.

7. Ancillary fishing industry information

8.306 If the fishing industry is of particular importance to an economy, in addition to drawing up accounts showing the physical and monetary characteristics of the fish stock, there are other variables that it would be helpful to document and present at the same time, including information about the nature of the industry showing whether its activities are all organized formally or whether and to what extent artisanal fishing is important. When artisanal fishing is significant, it is useful to know how much of it is undertaken for own consumption as a form of subsistence activity and how much is undertaken for the purpose of selling the catch, in which case artisanal fishing represents market activity, albeit if of an informal nature.

8.307 It may also be useful to document the extent of employment in the fishing industry and the number and type of fishing boats in use. Further, it would be of interest to know whether a country is self-sufficient in fish, or even a net exporter of fish, by comparing production with consumption, imports and exports.

8.308 It may also be desirable to identify expenditures for the management of fish stocks or those for the protection of the aquatic ecosystems. The former would comprise expenditures for research for fisheries management purpose, monitoring, control and surveillance, data collection and statistics, and costs of the fisheries management authority (local, national and regional) as well as temporary costs for facilitating structural adjustments of the fishery-related industries (for example, vessel buy-back programmes, retraining etc.). Environmental protection expenditures would include expenditures geared towards the protection of the habitat and water quality of the aquatic ecosystem. Examples of categories in CEPA that may refer to fisheries are “Protection of ambient water” and “Protection of nature and landscape” (United Nations and Food and Agriculture Organization of the United Nations, 1999).

F. Land and ecosystem accounts

1. Role of land and ecosystem accounting

8.309 In the SNA, land is treated as a non-produced asset that provides economic benefits to its owner. It contributes a significant part to the total wealth of the nation. As there is a discussion of the problems of valuing land in section VII.E, the discussion will not be pursued further here.

8.310 In environmental accounting, land viewed as providing economic benefits is only part of the picture. The economic use of land is often connected with short- or long-term processes of deterioration (or improvement): for example, the opening of uncultivated land (such as virgin forests or wetlands) for recreational or agricultural purposes may upset ecological balances, the use of land for transportation or human settlement may radically change its characteristics, and agricultural use may cause soil erosion. On the other hand, the introduction of less intensive management practices (for example, organic farming) or restoration activities may lead to improvements. A better understanding of the relationship between economic activities and the environment requires that both the use of land by different economic activities and the potentials of land from an ecological perspective be taken into account. The latter relates, for example, to the extent and quality of habitats and ecosystems or the characteristics of the soil.

8.311 Land and ecosystems are closely related environmental assets. From an economic and ecological point of view, the value of assets that deliver services to human systems (indirect use benefits) over the long term depends heavily on complete ecosystems and not on individual species or elements. However, it is often difficult to find suitable indicators even in physical terms to describe some of these aspects. It is relatively easy to record the quantities of residuals that are emitted into the natural environment; it is much more difficult to describe the effects of ambient concentrations that result in a contamination of biota and soil and the final effect on health of biota, ecosystems and human beings.

8.312 A comprehensive set of land and ecosystem accounts links the economic and the environmental dimensions and permits aggregated indicators to be derived. These indicators can provide the background for land-related policies, inter alia, nature protection, agricultural and transport.

8.313 In general, the integration of a comprehensive land and ecosystems accounting module in the SEEA is useful for several reasons:

(a) It provides a complete picture of land cover and land use for a nation and allows the derivation of trends and indicators of change;

(b) It aids the integration of diverse sources of data on land cover and land use as well as the integration of those data with other data (for example, on population, economic activity, water balances, species or fertilizer use);

(c) It promotes the standardization and classifications of land cover, land use and the causes of changes in land cover and land use;

(d) It allows changes in land use, land cover, habitats and biodiversity to be linked as far as possible to driving forces;

(e) It can be applied at the national, the regional, the watershed or the landscape-type level.

8.314 In the following subsection, general features of accounting for all land and ecosystem categories are described. More details on integrated descriptions of selected land and ecosystem types can be found in the earlier sections on forest, fishery and water accounts.

2. State of development of land and ecosystem accounting

8.315 The concepts required for the description of land as an economic asset are well developed in the SNA and practical experience exists on implementing these concepts. Land statistics in general have a long tradition. They are compiled to satisfy the needs of many diverse users and, as a result, different definitions, classifications and methods are used in different countries.

8.316 The economic treatment of land in the SNA is straightforward from a conceptual point of view: land as a non-produced asset is defined as the ground itself, including the soil covering and the associated surface water. A high-level classification with four types of land is included in the SNA asset classification: land underlying buildings and structures; land under cultivation; recreational land and associated surface water; and other land and associated surface water.

8.317 The development of land and ecosystem accounts that adequately deal with the complexity of land and ecosystems as environmental assets is new and closely linked to the appearance of geo-referenced land-use or land-cover data[29]. A general consensus on the need for, and the basic structure of, a comprehensive approach to land and ecosystem accounting is emerging within and between many countries. On the other hand, there are conflicts concerning the use of land and ecosystems which are often characterized by specific regional or national interests or circumstances. This results in a large heterogeneity of observation methods, reporting formats and data available at these different levels.

8.318 Environmental impacts resulting from the deposition or emission of harmful substances (such as nutrients, toxics and other pollutants) may be different according to local environmental conditions. This is also true for other pressures resulting from natural resource-related activities, through either

[29] A major input has been the work undertaken by the Conference of European Statisticians from 1992 to 1994 and the subsequent discussions in meetings of the International Association for Research in Income and Wealth and of the London Group on Environmental Accounting.

withdrawal and operation or in situ use, including land use (Parker and others, 1996). The focus of policy interest in land and ecosystems accounting is therefore not restricted to general tables with a high level of aggregation; it often focuses on issue-oriented accounts (for example, for biodiversity, quality of land and habitats) or accounts by region (for example, catchment areas, coastal zones), which require more detail.

8.319 Land and ecosystem accounts will be characterized by a compromise between standardization and flexibility, for it is extremely difficult to develop a single standard land classification that satisfies the different needs of all users in a meaningful way. Cooperation among statisticians, economists, geographers and biologists, as well as flexibility in adjusting the accounts to the available data sources and the classifications that they use, is therefore essential in the implementation of land and ecosystem accounts. Data sources available may include information derived from satellite images, aerial photographs, maps and data sets based on field surveys or cadastral administrative databases.

3. Observation units and classifications

8.320 A special feature of land and ecosystem accounting is the extremely close link between the objectives of the studies and the determination, in light of the specific objective, of the observation or accounting units and classifications used.

Land cover and land use

8.321 A basic distinction in land and ecosystem accounting is that between land cover and land use. Land cover reflects the (bio) physical dimension of the earth's surface and corresponds in some regard to the notion of ecosystems. Typical examples for land-cover categories are built-up areas, grassland, forests or rivers and lakes. Land use, on the other hand, is based on the functional dimension of land for different human purposes or economic activities. Typical categories for land use are dwellings, industrial use, transport, recreational use or nature protection areas.

8.322 Land use is a more complex issue than land cover because of the different functions that a single land cover unit can fulfil. Often, there are parallel or multiple land uses, in particular with regard to recreation/tourism and to use restrictions due to the protection status of land. A forest, for example, serves to provide timber, regulate climate and water regimes, sequester carbon dioxide, retain soil, provide habitat for wildlife and fulfil recreational functions. Land use in terms of human activities may result in changes either in biophysical land cover (for example, deforestation, creation of transportation corridors, urbanization) or in the conditions of the natural or modified biotopes (due, for example, to the use of fertilizers or pesticides or to leaving land fallow, to the intensity of traffic on a road, or to the density of population in a town). These trade-offs among functions of natural assets are one of the focuses of the ecological-economic interrelationships that are studied in environmental accounting.

8.323 Land cover results from the use of land through both activities and natural processes, whether modified by human activities or not (Conference of European Statisticians, 1995). Land cover is normally observed by satellites aerial photographs and ground surveys. Information on land use is gathered by cadastral surveys, surveys of economic units, aerial photography and/or ground surveys.

8.324 The distinction between land use and land cover is basic from an analytical point of view. Statistical work, however, is often characterized by more or less mixed classifications of land use and land cover. In principle, land use can be better linked to economic activities. Sometimes, land cover on a large scale is considered a proxy for land use. Often built-up areas are encompassed to larger extent by the land use oriented parts of the classification, whereas the disaggregation of more natural categories (such as forest and woodland, wetland and semi-arid and arid land) are more reflective of land cover-related aspects. Sometimes, the whole mixed classification is more use- or more cover-oriented. When a primary or dominant use is hard to determine, multiple allocation or a separate multi-use recording can be considered.

Observation units

8.325 Land-use and land-cover data are produced for different observation units. In the SNA, the basic units for land are not explicitly discussed. The type of land use and ownership is usually documented in land registers based on legal units or can be surveyed by questionnaires sent to economic units.

8.326 In environmental accounting, additional types of land units are used. Land-cover or ecosystem-oriented presentations use land registers, aerial photographs and field surveys as well as geo-referenced satellite data. In all information systems, the scale of the study determines the delimitation and the homogeneity of the basic land units. Land units are defined as surface areas with certain cover characteristics. At a small or medium scale, the land-cover units are largely composite and must be classified according to their main characteristics (including, possibly, mixed classes). They could be regarded as ecosystems on a higher hierarchic level. In studies at large geographical scales including fieldwork, rather homogenous land units such as biotopes are common. In the economic sphere, the same type of unit can apply to both a multinational firm and a small family enterprise. In land accounting, however, no consensus is available on the "ideal" type of unit and the fact that different objectives of analysis require different basic units is widely recognized. A consensus on the choice of biotopes, ecosystems and more heterogeneous land cover units as basic units for land-cover seems to be emerging. In some cases, land-cover or land-use aspects are combined with geometrical units (for example, grids of one km) that are determined by the dominant type of land use or cover.

Ecosystems

8.327 Ecosystems are inhabited spaces and cover both the abiotic biotopes and the biocoenosis for communities – in other words, the ecosystems' organisms. Ecosystems are best seen as the systems of interactions between the abiotic habitat and the organisms (flora and fauna) in a spatial unit. The holistic system does not react in the same way as its individual components would. Ecosystems can be defined for different hierarchic levels. Examples of higher-ranking ecosystems are the sea, the forest, the meadow etc., with all the organisms that live there and their interactions. Such systems consist of subsystems (for example, pond, river, marshland etc.). The notion of an ecosystem, however, is not restricted to the more natural parts of the land. In principle, it covers all types of land including urban ecosystems. There is no classification that allows the theoretical notion of "ecosystem" to apply to a clear-cut separate geographical entity in the landscape. Depending on the relief, the species of fauna etc., different geographical demarcations will be applied. Biotopes in the strict sense of the word are abiotic areas that can be clearly defined geographically and that feature a combination of specific abiotic non-living factors (regarding climate, soil, light, temperature, water, nutrients etc.). They therefore offer specific habitat conditions for organisms. Biotopes, in the pragmatic sense in vegetation science, incorporate both the spatial components and the vegetation within an area, that is, the parts of the biocoenosis. They are typically land-cover units. Where there are no plants, the existing abiotic land cover (for example, buildings, roads, landfills or glaciers) is used for descriptive purposes. The notion of biotope is not restricted to protected areas or areas of particularly high ecological value. It covers the total land of a country.

8.328 For a pragmatic differentiation of units of ecosystems at a low hierarchic level, the biotopes (in the sense of vegetation units) are often used. At a higher hierarchic level, the more heterogeneous land-cover units or ecozones (or even the biogeographic regions of the world) can be interpreted as ecosystems (Hoffmann-Kroll and others, 1999). In land accounting, more heterogeneous land cover units are often used. They can be understood as aggregates of connected biotopes, where the dominant type of biotope determines the land-cover class. In Europe, for example, the project CORINE Land Cover is based on satellite data and on basic units with a minimum size of 25 ha and a classification of 44 different land-cover categories. In this context, large areas with the same land-cover class are often described as ecozones or landscapes (for example, agricultural ecozones or landscapes). As species are part of the ecosystems, they are included twice in the asset classification of the SEEA, once as individual plants or animals in the biotic natural resources and again as parts of ecosystems.

Classifications

8.329 In the SEEA classification of assets, land and ecosystems are included twice: once as land and surface water (area) and, again, as ecosystems. Soil is also included separately as a natural resource.

8.330 Land characterizes the space used in human activities. The SNA includes only land that provides a direct input into human activities. In the SEEA, five major types of land resources are distinguished:

(a) Land underlying buildings and structures (EA.21);

(b) Agricultural land and associated surface water (EA.22);

(c) Wooded land and associated surface water (EA.23);

(d) Major water bodies (EA.24);

(e) Other land (EA.25).

8.331 The asset classification in annex I provides a further disaggregation of the above categories. The total area of a country is shown as naturally divided between the five categories listed above.

8.332 In the asset classification of the SEEA, ecological aspects of land, the aspect of land cover and the provision of services to humans are taken into consideration by the inclusion of terrestrial and aquatic ecosystems. They are identified separately and are further subdivided into five major types of biographic regions to be found on the planet. More detailed classifications that could be used in environmental accounting on a national or a regional level have to be based on the definition of the corresponding observation units and the scale of observation. At the moment, internationally agreed land-cover classifications are available from FAO and for selected regions, for example, the Coordinated Information on the European Environment (CORINE) land-cover classification for Europe. A complete and internationally agreed biotope or ecosystem classification is not yet available, nor have the different regional land-use/land-cover classifications been standardized.

8.333 For land use in general, the more detailed ECE land-use classification should be used. This classification is better suited to the analysis of types of land use with different environmental impacts rather than for the land classification in the SNA. However, the ECE classification is not entirely satisfactory, and several international organizations (such as FAO and Eurostat) were working towards the production of an improved land-use classification at the time of the writing of this Handbook.

8.334 Countries will differ considerably in terms of both the main and the detailed classifications for land use, land cover and landscape types. For example, forests may be of major or of very minor importance for a country. National data sources available for land accounts will use classifications that are already adapted to the characteristics of that country.

4. Structure of the land and ecosystem accounts

Overview and basic accounts

Overview

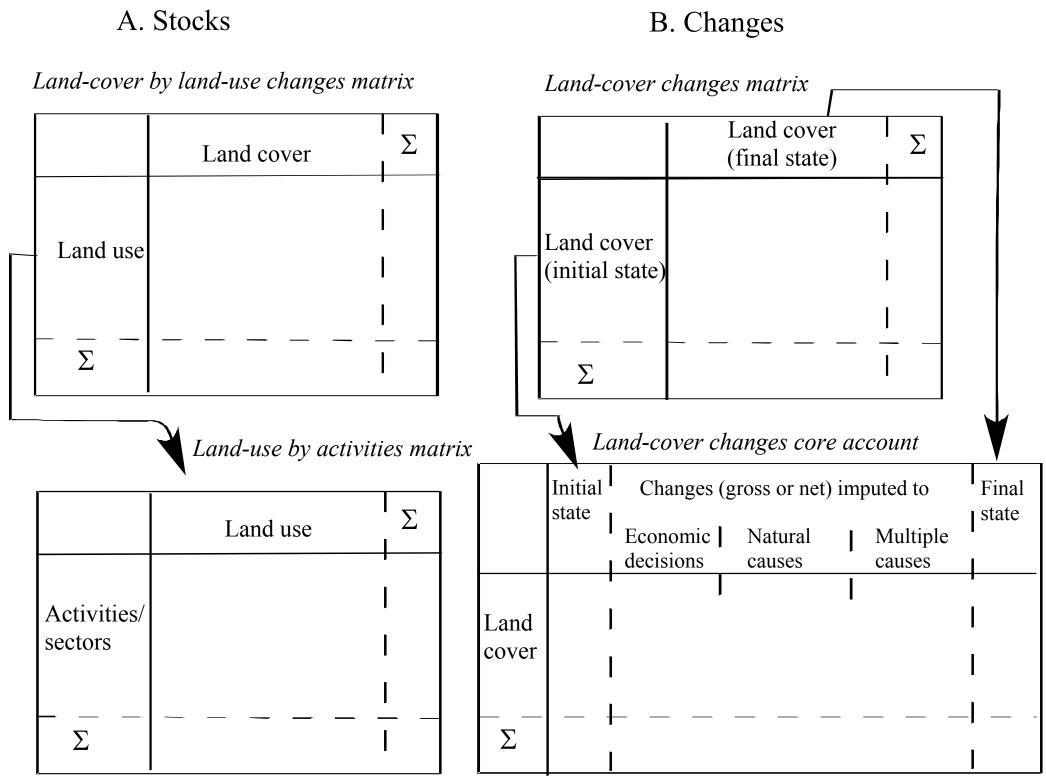
8.335 Although market price valuations are relevant when assessing the economic aspects of nature as a fixed asset, they are not suitable for representing ecological aspects. Market prices are based on human use and exploitation potential and do not reflect the ecological significance of an area. Areas of high ecological value that are protected or use-restricted have considerably lower market prices than unprotected agricultural land or city centres heavily used for economic purposes. For purely environmental accounting, priority is often given to physical accounts that measure land in units of surface area (hectares or square kilometres) or, in some cases, in terms of length or number of units (zones, biotopes etc.).

8.336 The following subsection presents basic accounts of land use and ecosystems whose layout it would be desirable to standardize across countries. From an environmental point of view, information obtained from basic accounts is necessary but often not sufficient in formulating and monitoring policy. For this reason, supplementary accounts that are issue-oriented and take into account national and regional situations as well as the availability of data are introduced into the classification used. Supplementary accounts cannot be standardized to the same extent as the basic accounts owing to their nature, but they are made consistent with the basic accounts. In the case of ecosystems accounting, for example, the land-cover aspect is included in the basic accounts and biotope accounting in the supplementary accounts. Since supplementary accounts are often indispensable for users, they form an important part of land and ecosystem accounting. The distinction between basic and supplementary accounts involves a compromise between standardization and flexibility. As experience develops, future proposals for standardization may be made.

Basic accounts

8.337 For land and ecosystem accounting, basic accounts establish the interface between land use and land cover from an environmental perspective. The different aspects treated in this context are shown in Figure 8.5. The relation between land use and land cover and between land use and economic activities in terms of stock levels is shown. There are tables (see box in lower right of Figure 8.5) showing the change in land classified to each type of land cover over a period in terms of changes in stocks, and an identification of the processes to which this is due whether human or natural.

Figure 8.5. Structure of the basic set of land-cover/land-use accounts



Source: Conference of European Statisticians (1995), p. 6.

8.338 Detection and indication of changes in land use and land cover are key aspects of land accounting. Often significant changes in land cover and land use are observable only over a longer timescale. Therefore, the land and ecosystem accounts are often compiled only every four or more years, whereas data on an economic asset based on land use may be available and analysed on a yearly basis. In land accounting, the notions of initial and final year are sometimes more appropriate than those of opening and closing stocks. The land accounts in physical terms allow a much better understanding of the environmental developments over time than accounts in monetary terms.

Land use/land cover

8.339 The presentation of a land use by land cover matrix relates to a single point in time. Table 8.27 constitutes a land use by land cover matrix based on the categorization of land and of ecosystems in the SEEA asset classification. For some categories of land cover, for example, arable land and permanent crops, the link of the cover to one use category (primary production) is quite evident. For others, for example, slightly artificialized areas, the table indicates the importance of different types of use or the part of the area that is not used at all. The compilation of this table assumes geo-referenced basic data for land use and land cover either on the total area of a country or for a given area.

Table 8.27. Land use/land cover

EA.3 Land cover (ecosystems)		*EA.2 Land use* EA.21 Land underlying building and structures	EA.22 Agricultural land	EA.23 Forest land	EA.24 Major water bodies	EA.25 Other land	**Total**
EA.31 Terrestrial ecosystems	EA.311 Urban	108	2	1			**111**
	EA.312 Agricultural		326				**326**
	EA.313 Forest	6	25	278			**309**
	EA.314 Prairies and grassland	15	133				**148**
	EA.315 Tundra						
	EA.316 Dryland	1				9	**10**
	EA.317 Other					75	**75**
EA.32 Aquatic ecosystems	EA.321 Marine						
	EA.322 Coastal						
	EA.323 Riverine	1	3	1	9	1	**15**
	EA.324 Lacustrine		1		3		**4**
	EA.325 Other				2		**2**
Total		**131**	**490**	**280**	**14**	**85**	**1 000**

Note: Constructed land example.

8.340 Most countries will be able to fill in only the column and row totals, sometimes supplemented by limited information inside the matrix. The compilation of the table is in fact very data-demanding. If data are available only for a single classification that mixes land use and land cover, Table 8.27 will in practice be a diagonal matrix. If more detailed classifications and different data sources for land use and land cover exist, their combination will provide extra insights.

Land use by industries and households

8.341 The second basic table on stock levels (Table 8.28) links land use to economic activities. In this context, land is regarded as a production factor rather than as part of a balance sheet. As a consequence, the presentation is normally based on the actual use of land (not on ownership) in the production and consumption processes. It is restricted, however, to physical data (surface area).

Table 8.28. Land use by industries and households

Industries (ISIC) and households	Land use as in SEEA classification: EA.21 Land underlying building and structures	EA.22 Agricultural land	EA.23 Forest land	EA.24 Major water bodies	EA.25 Other land	**Total**
Agriculture, hunting, forestry, fishing (A+B)	21	470	160	2	2	**655**
Mining quarrying (C)	1				1	**2**
Manufacturing, electricity (D+E)	10					**10**
Construction (F)	4					**4**
Wholesale, retail trade, repair motor vehicles, hotels and restaurants (G+H)	6					**6**
Transport, storage, communication (I)	3			4		**7**
Financial intermediation, real estate, other business services (J+K)	3					**3**
Education, health, social, personal services (M+N+O+P)	4					**4**
Public administration, defence, social security, other public services (L)	1					**1**
Private households[a]	74		40	2	1	**120**
Subtotal	**127**	**470**	**200**	**8**	**7**	**812**
No direct use	4	20	80	6	78	**188**
Total	**131**	**490**	**280**	**14**	**85**	**1 000**

Note: Constructed land example

[a] User-oriented concept, including residential land and public area used by private households.

8.342 In principle, different options exist for the allocation of land to industries and households. One option is to closely follow national accounts classifications and categories (for example, those based on ownership for transport infrastructures or recreational areas). Another option is to proceed in a more use-oriented way by allocating areas for selected public goods (for example, roads and parks) to the units that actually use these areas. Subsequently, indirect land use linked to land used by industries producing intermediate goods can be included in the analysis.

8.343 A land use by economic activities matrix can be estimated on the basis of non-geo-referenced data as well. A precondition is that the use-oriented categories of the classification be highly disaggregated and that other basic data (for example, on land for housing, kitchen gardens, use of land by industries from housing and industry surveys) be available or capable of estimation in a reliable way.

8.344 A table on land use by industries (or products) and households allows, for example, indicators for land productivity (value added per unit of land used) to be derived. However, the rules of allocation of land to producers (industries) on the basis of actual use are sometimes difficult to determine, and standards are not yet fully developed (see Krack-Roberg and Schäfer, 1999; Leurs and van Dalen, 1998). Often, there are multiple uses, in particular with regard to recreation (for example, agricultural land, forests or waters may be used for several purposes) or protected areas. It is sometimes hard to determine a “primary” or “dominant” use, so that multiple allocation or a separate recording of multiple uses could be considered.

Land-cover change matrix

8.345 The land-cover change matrix presented in Table 8.29 cross-tabulates land-cover at two different points in time. It shows how much of the opening stock of a land-cover category is still the same in the closing stock and the gross flows between the different categories of land cover. The total increase, the total decrease, the total change (increase + decrease) and the net change (increase – decrease) can be calculated from this table. The same analysis can be carried out for land-use changes. The production of such a table has normally to be based on geo-referenced data sources because land cover on each unit in the opening stock (initial year) and in the closing stock (final year) must be known and analysed for its use to be seen. The analysis can in principle be carried out on the basis of the total area or of a sample. In the latter case, the size of the sample determines to what extent the gross flows can be assessed reliably.

Changes in land cover by categories of changes

8.346 The land-cover change matrix forms the ideal starting point for developing an analysis of the causes of changes in land cover (or land use). Table 8.30 provides an illustration of possible changes (Eurostat, 1999). So far this is another area where standard classifications on the types of changes are not readily available at the international level: only selected national approaches exist. Table 8.31 presents a land-cover account for Great Britain as an example of a national application. The account is based on a random stratified sample of 502 areas of one square kilometre each surveyed in both 1990 and 1998 as part of the national Countryside survey (Haines-Young and others, 2000). The account uses classifications specifically adapted to the types of land cover and land-cover changes in that country.

8.347 From the stock accounts, net flows between the opening and closing stocks can be established. However, it is important from an ecological point of view to show increases and decreases separately because the replacement of “old” nature (old growth forest, for example) by “new” stocks (through reforestation, for example) is normally linked to a considerable change in ecological quality.

8.348 In general, two levels of changes with respect to categories of land use or land cover can be distinguished. Changes in classification are referred to as external changes and changes within categories as internal changes. External changes are described in the basic accounts. They can be described to some extent by more detailed classifications of land use and cover. Internal changes will typically be described in supplementary accounts. To some extent, the more detailed the classifications used, the larger the part of the total changes can be covered by the external changes in the basic accounts (Eurostat, 1999).

Table 8.29. Land-cover change matrix

	Land cover (final year)															
Land cover (initial year)	**EA.31 Terrestrial ecosystems**	EA.311 Urban	EA.312 Agricultural	EA.313 Forest	EA.314 Prairies and grassland	EA.315 Tundra	EA.316 Dryland	EA.317 Other	**EA.32 Aquatic ecosystems**	EA.321 Marine	EA.322 Coastal	EA.323 Riverine	EA.324 Lacustrine	EA.325 Other aquatic ecosystems	**Total (initial year)**	**Decrease**
EA.31 Terrestrial ecosystems																
EA.311 Urban		69	2	2	6			1							**80**	**11**
EA.312 Agricultural		20	307	15	25			8							**375**	**68**
EA.313 Forest		4	1	285	3			12					1		**306**	**21**
EA.314 Prairies and grassland		9	11	4	114			3							**141**	**27**
EA.315 Tundra																
EA.316 Dryland				2			10								**12**	**2**
EA.317 Other			8	2	3			51							**64**	**13**
EA.32 Aquatic ecosystems																
EA.321 Marine																
EA.322 Coastal																
EA.323 Riverine			1									15			**16**	**1**
EA.324 Lacustrine		1											3		**4**	**1**
EA.325 Other														2	**2**	**0**
Total (final year)		**111**	**326**	**309**	**148**		**10**	**75**				**15**	**4**	**2**	**1 000**	**144**
Increase		**42**	**19**	**24**	**34**		**0**	**24**				**0**	**1**	**0**	**144**	
Total change (Increase-decrease)		**53**	**87**	**45**	**61**		**2**	**37**				**1**	**2**	**0**	**288**	
Net change (Increase-decrease)		**31**	**-49**	**3**	**7**		**-2**	**11**				**-1**	**0**	**0**	**0**	

Note: Constructed land example.

8.349 The analysis of the causes of changes in Table 8.30 is restricted to external changes. The table can be compiled using geo-referenced land data for all units of the total area or for a permanent sample of units and data on gross changes. This type of data is actually more often available for land cover than for land use. For every unit, the cover category of the initial stock (opening stock) and that of the final stock (closing stock) are identified. If they are different, the change is allocated to a type of change according to fixed allocation rules.

8.350 To carry out this procedure, individual data on gross flows are required. In traditional, non-geo-referenced land statistics, only the net flows are available hence in the physical accounts the types of changes cannot be derived.

Table 8.30. Changes in land cover by categories of change

Land cover	Initial stock	Increase								Total	Decrease								Total	Final stock
		Changes due to economic decisions	Artificialization/urbanisation	Changes in agricultural practices	Restoration and rehabilitation	Changes due to other causes	Multiple causes	Natural causes	Catastrophic causes		Changes due to economic decisions	Artificialization/urbanization	Changes in agricultural practices	Restoration and rehabilitation	Changes due to other causes	Multiple causes	Natural causes	Catastrophic causes		
EA.31 Terrestrial ecosystems																				
EA.311 Urban	80	42	42			0				42	9	2	2	5	2		2		11	111
EA.312 Agricultural	375	19		19		0				19	56	24	22	10	12	3	9		68	326
EA.313 Forest	306	18			18	6	1	5		24	20	4	3	13	1			1	21	309
EA.314 Prairies and grassland	141	30	6	24		4	1	3		34	27	9	11	7	0				27	148
EA.315 Tundra																				
EA.316 Dryland	12	0				0				0	2		2		0				2	10
EA.317 Other	64	19			19	5	1	3	1	24	13	8	2	3	0				13	75
EA.32 Aquatic ecosystems																				
EA.321 Marine																				
EA.322 Coastal																				
EA.323 Riverine	16	0				0				0	1		1		0				1	15
EA.324 Lacustrine	4	1			1	0				1	1	1			0				1	4
EA.325 Other	2	0				0				0	0				0				0	2
Total	**1 000**	**129**	**48**	**43**	**38**	**15**	**3**	**11**	**1**	**144**	**129**	**48**	**43**	**38**	**15**	**3**	**11**	**1**	**144**	**1 000**

Note: Constructed land example.

Table 8.31. Land-cover account for Great Britain, 1990-1998

	1990 stock	Types of change in stock: Woodland creation	Woodland rotation	Agricultural intensification	Agricultural rotation	Semi-natural creation	Semi-natural rotation	Water-body creation	Development	Developed land recycling	Loss to unknown	1998 stock	Change account: Reductions 1990-1998	Additions 1990-1998	Net Change 1990-1998	Stock unchanged since 1990, (percentage)
	1 371.2	132.4	13.5	-22.2		-42.1		-0.8	-12.9		-0.4	1 438.7	78.4	145.9	67.5	89.9
Coniferous woodland	1 369.3	67.2	-13.5	-9.0		-48.3		-0.6	-5.0		0.0	1 360.2	76.4	67.3	-9.1	95.1
Woodland subtotal	**2 740.5**	**211.6**	**0.0**	**-31.2**		**-90.4**		**-1.4**	**-17.8**		**-0.4**	**2 798.9**	141.2	211.5	**70.3**	92.9
Arable and horticultural	5 246.1	-28.8		59.2	118.2	-41.4		-1.0	-19.3		-0.2	5 332.9	90.7	177.6	86.9	96.7
Improved grassland	5 538.6	-34.1		341.0	-118.2	-232.0		-0.5	-53.9		-5.3	5 435.5	444.0	340.9	-103.1	93.7
Intensive agriculture subtotal	**10 784.7**	**-62.8**		**400.2**	**0.0**	**-273.4**		**-1.5**	**-73.2**		**-5.5**	**10 768.4**	**416.4**	**400.2**	**-16.2**	**96.3**
Neutral grassland	569.5	-24.4		-153.6		238.9	-18.2	-0.5	-33.2		-0.1	578.3	230.0	238.8	8.8	58.7
Calcareous grassland	81.4	-1.1		-13.3		3.7	-3.8	0.0	-0.2		0.0	66.7	18.4	3.8	-14.6	94.5
Acid grassland	1 470.9	-24.0		-133.7		43.3	-34.7	0.0	-4.6		-0.7	1 316.5	197.7	43.4	-154.3	96.7
Bracken	456.9	-21.8		-8.7		20.4	38.9	0.0	-0.5		0.0	485.1	31.0	59.2	28.2	87.8
Dwarf shrub heath	1 487.1	-24.5		-1.2		13.1	-41.4	0.0	-3.3		0.0	1 429.7	70.4	13.1	-57.3	99.1
Fen, marsh and swamp	456.4	-6.1		-25.1		61.0	71.3	-0.7	-1.2		-0.6	554.9	33.7	132.2	98.5	76.2
Bog	2 297.3	-17.9		-0.7		10.5	-10.1	-0.3	-0.2		-0.1	2 278.5	29.3	10.5	-18.8	99.5
Montane	49.8	0.0		0.0		0.0	0.0	0.0	0.0		0.0	49.8	0.0	0.0	0.0	100
Coastal habitats	274.1	-0.3		-0.8		2.6	-2.0	-0.3	0.0		0.0	273.3	3.4	2.6	-0.8	99.0
Semi-natural subtotal	**7 143.3**	**-120.1**		**-337.2**		**393.5**	**0.0**	**-1.8**	**-43.2**		**-1.5**	**7 032.9**	**503.8**	**393.4**	**-110.4**	**94.4**
Standing open water and canals	208.4	-0.2		-1.0		-0.9		5.2	-1.2		0.0	210.3	3.3	5.2	1.9	97.5
Rivers and streams	66.7	-0.2		-0.1		-1.4		0.3	-0.1		0.0	65.2	1.8	0.3	-1.5	99.5
Water bodies subtotal	**275.1**	**-0.4**		**-1.1**		**-2.3**		**5.5**	**-1.2**		**-0.1**	**275.5**	**5.1**	**5.5**	**0.4**	**98.0**
Inland rock	53.6	-0.6		-2.2		-7.6		0.0	13.2	3.8	0.0	60.2	10.4	17.0	6.6	71.8
Built-up areas and gardens	1 230.4	-14.2		-12.3		-9.4		-0.7	100.4	-2.1	-1.2	1 291.0	39.9	100.4	60.5	92.2
Boundary and linear features	495.0	-1.0		-14.5		-7.8		-0.1	21.9	-1.7	-0.1	491.7	25.2	22.0	-3.2	95.5
Developed subtotal	**1 779.0**	**-15.9**		**-28.9**		**-24.8**		**-0.8**	**135.5**	**0.0**	**-1.3**	**1 842.9**	**71.7**	**135.6**	**63.9**	**92.6**
Sea	298.5	0.0		0.0		-0.7		0.0	0.0		0.0	297.8	0.7	0.0	-0.7	100
Unknown	73.9	-0.3		-1.8		-2.0		0.0	0.0		8.8	78.6	4.1	8.8	4.7	88.8
Unsurveyed urban land	463.0											463.0	0.0	0.0	0.0	100
Total	**23 557.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**23 558.0**	**0.0**	**0.1**	**0.1**	**100**

Source: Haines-Young and others (2000).

8.351 Additional aspects can be added to the basic accounts to expand the analysis, for example, linear landscape features and regional accounts. Linear landscape features (for example, hedgerows and walls) are a typical example. Linear features are often rather poorly represented in land-cover classifications. Nevertheless, reporting on their quantity in the form of length units in some countries adds important information on significant elements in the landscape.

Data availability

8.352 A precondition for policy-relevant and scientifically sound land and ecosystem accounts is a good database with geo-referenced land-use and land-cover data. In practice, land-cover and land-use data are often presented in mixed classifications and most data are not geo-referenced. The use of mixed classifications means that it is impossible to construct land-use/land-cover cross-tabulations for fixed points in time. The absence of geo-referenced data means that it is impossible to construct land-use or land-cover change matrices showing the flows between categories of land use (or land cover) during a period; the most that can be done is to compile stock accounts for different points in time.

Supplementary accounts

General aspects

8.353 The supplementary accounts are strongly driven by policy interests. They can be divided into two groups. The first group encompasses problems of naturalness and intensity of land use. Phenomena such as sealing or fragmentation are incorporated and closer links to the economic activities are established in Table 8.28, which presents the basic land-use accounts by industries and private households. The focus of the second group is more closely related to land-cover aspects, the state of the natural environment or biotope accounting. Aspects such as biodiversity are included.

8.354 Geo-referenced data allow regional accounts, which are often of particular policy interest, to be derived. For describing land cover, environmentally relevant regional classifications like ecozones, landscape type units[30] or watersheds are widely used; for land use, administrative regions can also be relevant.

8.355 In general, supplementary accounts are characterized by the fact that they integrate land-use or land-cover data with data from a great variety of other economic and ecological data sources. In this regard, one of the problems in establishing ideal supplementary accounts often concerns the availability of well-suited data and statistical instruments or monitoring programmes. Compared with economic and social statistics or data on the pressures exerted by economic activities, data characterizing the quality of the environment are often fragmented.

Land use oriented accounts

8.356 In land use oriented supplementary accounts, the land-use parts of the basic accounts are differentiated in a consistent way by more detailed descriptions of issue-oriented aspects. The main themes are the description of changes in the artificiality of land and the link to human driving forces or pressures and the intensity of use of land. Typical issues in this context are the sealing of soil, the partitioning (fragmentation) of land by transport networks, and the impacts on land by industries, agriculture, tourism, transport and human settlements (Conference of European Statisticians, 1995).

[30] Landscape-type units are spatial units characterized by homogeneous natural conditions, for example, soil, climate, geology, hydrology or relief (Haines-Young and others, 2000; Schäfer and others, 2000).

Often both production patterns including technological aspects and consumption patterns have to be considered.

8.357 Soil sealing constitutes a good, simple example for explaining the relation to the basic accounts. In some countries, the sealing of soil is a major environmental problem, as the functions of the soil are totally disturbed. Typical consequences are the destruction of biotopes and impacts on microclimate and water balances. The units used to produce results for land use in the basic accounts are normally sealed to very different degrees. In the case of dwellings, for example, the ground area of the house is often completely sealed, whereas the garden around it is not or only to a very limited extent. To detect general trends of soil sealing in a country or in a region, the degrees of sealing of the different land-use (or even land-cover) categories have to be derived from other data sources (for example, by interpreting aerial photographs, housing statistics or field surveys) and linked to the volume of the different land-use categories. Depending on the objective, this can be done on the basis of the land-use classification in Table 8.27 of the basic accounts, a classification where single categories (for example, land underlying building and structures) are further disaggregated, or even in the context of Table 8.28, by economic activities.

8.358 Other data that can be integrated in the supplementary accounts are data on the intensity of use of agricultural, urban or infrastructure land as evidenced, for example, by the use of chemicals in agriculture, emissions, disposal of waste, extraction of water or other resources, transport-related information like traffic density and so on (for examples, see Conference of European Statisticians, 1995). An important feature of the supplementary accounts is that in many cases the issues demand data that are classified by region or even geo-coded. The detail of geographical referencing determines the detail of possible accounting (Parker and others, 1996).

Land cover oriented accounts

8.359 In the land cover oriented supplementary accounts, the information in the basic accounts is extended by describing in more detail the potentials of land and aspects of biodiversity. The potentials of land relate to the richness of natural habitats in terms of extent of biodiversity, to their vulnerability, to the characteristics of the soil, and to the social and economic activities that it supports. The potentials can be assessed from several points of view, one of them being the capacity of the landscape to sustain natural life under the pressure of human activities (Parker and others 1996). In the case of the cover-oriented accounts, the link to economic activities and pressures is more difficult to establish than in the case of use-oriented accounts. Data on biotopes, and flora and fauna, and information on the natural conditions in a country or region (climate, soil, water etc.) are important inputs to the land cover oriented accounts.

8.360 For analysing land cover or ecosystems on a more sophisticated level, more homogenous land units are used. Biotope accounting is a very important example in this regard. Biotope accounts are normally better targeted to nature conservation policy or to (ecosystem) theory than land-cover descriptions. The link to the basic accounts can be established by a table cross-classifying land cover and biotopes in the same way that Table 8.27 of the basic accounts cross-classifies land use and land cover. As in the basic accounts, a biotope change matrix (corresponding to Table 8.29) and a table indicating the causes of changes (corresponding to Table 8.30), distinguishing human influences from natural developments, can be produced. Basic data in biotope accounting are often geo-referenced (Stott and Haines-Young, 1996; Seibel and others, 1997).

8.361 Table 8.32 constitutes an example of such a cross-classification of land cover by major biotope types based on the results of the Countryside survey in Great Britain (Haines-Young and others, 2000). The data show the number of random vegetation plots sampled in 1998. The land-cover types refer to the parcel of land from which the vegetation was sampled as determined by field survey. The biotope type refers to a statistical classification of the classification of vegetation based on species composition. Some of the land-cover types, such as broadleaved woodland, consist of a mixture of vegetation types. Repeat surveys in 1978, 1990 and 1998 enabled assessment of changes in extent and ecological condition of land-cover types (Haines-Young and others, 2000).

Table 8.32. Cross-classification of land cover and biotope types, Great Britain, 1998

	Biotope type								
Land-cover type	Crops and weeds	Tall grass and herb	Fertile grassland	Infertile grassland	Lowland wooded	Upland wooded	Moorland grass	Heath/ bog	Total
Broadleaved woodland	3	18	7	23	70	60	10	5	**196**
Coniferous woodland	0	5	1	4	12	92	29	30	**173**
Arable	442	89	51	6	0	0	0	0	**588**
Improved grassland	23	18	384	315	0	0	12	0	**752**
Neutral grassland	7	8	10	57	0	8	4	2	**96**
Calcareous grassland	0	0	0	9	0	0	1	0	**10**
Acid grassland	0	0	2	25	0	10	119	51	**207**
Bracken	0	0	0	12	1	31	23	9	**76**
Dwarf shrub heath	0	0	0	2	0	13	82	143	**240**
Fen, marsh, swamp	0	5	2	26	0	5	41	16	**95**
Bog	0	0	0	1	0	4	50	239	**294**
Total	**475**	**143**	**457**	**480**	**83**	**223**	**371**	**495**	**2 727**

Source: Haines-Young and others (2000).

8.362 An important aspect of biotope accounting is the integration of quality indicators, for example, on biodiversity aspects. Changes in biodiversity are most often a consequence of human activities, but only the diversity of species can be integrated in biotype accounts. To include habitat diversity – which can be understood as diversity of biotopes in a landscape – in land and ecosystem accounts, more heterogeneous landscape units like ecozones or landscape-type units have to be described by the corresponding quality indicators. In the case of biodiversity, the parallel use of different accounting units is therefore essential (Hoffmann-Kroll and others, 1999).

8.363 Table 8.33 presents an example of a biodiversity indicator linked to land cover and biotope accounts in Great Britain. It shows the mean number of plant species recorded in the same vegetation plots sampled in both 1990 and 1998. The vegetation plots are classified according to the biotope type present in 1990 and linked to land-cover types. In this example, "moorland grass" has the highest overall species richness and "crops and weeds" the lowest. Statistically significant declines in species richness occurred in "tall grass and herb", "fertile grassland" and "infertile grassland" biotopes. This is one of the core indicators used in the sustainable development strategy of the Government of the United Kingdom of Great Britain and Northern Ireland (Haines-Young and others, 2000; United Kingdom Department of the Environment, Transport and the Regions, 1999).

8.364 In general, the surface area accounts for landscapes and ecosystems or biotopes that are required to reflect biodiversity can be linked not only to diversity indicators but also to the relevant material (for example, degradation by residuals) or functional indicators for describing the state of the environment. It leads to a systematic, theory-based description of the state of environment, which would extend (from a conceptual point of view) the current data-reporting conducted on a media or sectoral basis.

Table 8.33. Example of a biodiversity indicator

Biotope type	Mean species number per plot 1990	1998	Percentage change 1990-1998
Crops and weeds	5.6	6.2	10.9
Tall grass and herb	14.7	13.5	-8.1
Fertile grassland	13.1	12.3	-5.6
Infertile grassland	19.9	19.1	-4.0
Lowland wooded	12.1	11.9	-1.5
Upland wooded	13.4	13.4	-0.4
Moorland grass	20.4	20.7	1.5
Heath/bog	14.5	14.5	0.1

Source: Haines-Young and others (2000).

Integration of quality aspects

8.365 The integration of quality aspects of land is a common feature of both land use- and land cover oriented supplementary accounts. Quality aspects can be integrated directly in an accounting structure based on surface areas only to the extent that they can be described by more detailed classifications based on quality. (See the discussion on this in the section on water accounts also). However, there are two clear limitations to such an approach of general, aggregated quality classes from a methodological and practical point of view.

8.366 Often, there are no concise breakdowns by complex quality classes of land or ecosystems types that are scientifically sound. For forest ecosystems, for instance, the health of the trees, the soil, the abundance of wild plants and animals and the state of the soil would all have to be considered. Given the current state of the art, a quality classification encompassing these aspects would be feasible only if normative standards as well as statistical descriptions were applied for the aggregation of the individual factors to quality classes.

8.367 Because of the combination of the various quality characteristics, any attempt to avoid normative elements in the assessment by cross-classifications results in a very large number of quality classes. At present, it would be unrealistic and/or extremely costly to quantify these in a reliable way.

8.368 The only practical approach is a pragmatic one. The surface area of ecosystems or land-cover units can be depicted by integrated accounting methods, whereas the indicator method is used for any further qualitative differentiation of these units. If suitable non-additive quality indicators are defined for the classes used for describing land use, land cover or biotopes in the corresponding accounts, the quality indicators can be added to the surface values as separate columns in stock matrices. From a methodological point of view, this approach is similar to monetary valuation in the treatment of land as an economic asset, in which price, as an expression of productivity of land, in the additive measure. In contrast, from an ecological point of view, internal quality is expressed by different quality indicators.

8.369 This approach opens the field to a large number of policy relevant analyses by combining the advantages of accounting and indicator methods. For example, aspects of biodiversity (especially habitat and species diversity) can be reflected by accounting methods only to a very limited extent. A consistent methodological link between accounting methods such as surface area balances and the respective biodiversity indicators is necessary for a satisfactory result. Some examples of indicators that give a clear idea of the kind of links between area balances and quality aspects follow. The biodiversity of habitats in a landscape or ecozone (heterogeneous land-cover units), on the one hand, can be recorded by indicators such as the naturalness of landscape (percentage of area covered by natural and mostly natural biotope types), biotope diversity of landscape (number of non-technical biotope types), length of linear features/verges, number of small biotopes or occurrence of endangered biotopes (in percentage of area). On the biotope level, biodiversity of species can be characterized by indicators such as the mean number of species (in biotopes or sample units in biotopes), the share of endangered species (as mean number or percentage of all species) or the share of specific strategy types that describe the stress to which, for example, plants are subjected (see Hoffmann-Kroll and others, 1999, or for some other indicators, Haines-Young and others, 1996).

8.370 Another policy-relevant example is soil degradation. Soil degradation is defined as a process that lowers the capacity of the soil to produce goods and services. The two categories of soil degradation are displacement of material by water or wind erosion and soil deterioration by chemical or physical processes. Examples of indicators used in the supplementary accounts to cover the aspect of chemical deterioration of soils are loss of nutrients and/or organic matter, salinization, acidification, pollution, acid sulphate soils or eutrophication (see United Nations (2000), especially paragraph 299, for the link among soil, land, socio-economic data and data on natural conditions).

8.371 In general, the degree to which quality indicators are combined with the accounts depends on the objectives of the analysis: in environmental accounting, a more limited use of quality indicators than in natural science reporting systems on the state of environment is normally adequate.

5. Integration of soil

8.372 In the SNA, soil is treated as an integral part of land and not as a separate economic asset. If the quality of soil is important for the use of land – for example, agricultural or forest land – then, the quality of soil becomes a factor influencing the price of land. There is some consideration given to this in section VII.E within the discussion of the valuation of land and the effects of degradation on it.

8.373 In the asset classification and in the physical accounts of the SEEA, soil is recognized explicitly as a distinct natural resource. This reflects the quantitative dimension of soil, in this case, for example, of soil erosion as a consequence of the reduction in the availability of soil at a given site through direct human use. Physical flows connected with soil erosion are treated as involving a decrease in soil in one area and an increase in the soil of the area to which the soil has been transported by wind and water. This underlines the character of soil as an asset that is, in principle, depletable. On the other hand, the use of soil is different from that of sand and stone extracted by the mining industry.[31] The negative impacts of soil degradation are integrated in the land and ecosystem accounts also. The qualitative dimension of soil (type of soil, nutrients etc.) is an important aspect of all terrestrial ecosystems. If soil erosion is included in this type of analysis, it is done more under the aspect of surface area (in hectares) that is affected by erosion problems or that runs a high risk of being eroded.

8.374 The way in which soil is included in environmental accounting, either as a separate natural resource or as part of land and ecosystem accounts, depends on the importance of the quantitative and qualitative dimension of soil in a country or region. For a more detailed presentation, see United Nations (2000, paras. 298-313).

[31] Though not entirely, since, to a limited extent, soil is sold in much the same way as sand and gravel are.

Chapter IX. Valuation techniques for measuring degradation

A. Overview

1. Objectives

9.1 Degradation is one of the three major environmental issues discussed in this Handbook, the others being depletion and defensive expenditure. Defensive expenditure puts a monetary value on environmental damage that is either prevented or rectified. The present chapter discusses how monetary values might be ascribed to damage that is neither prevented nor rectified. Much of the text is concerned with the practical issues of how such valuations can be attempted. Just as important, though, is the material in the present section explaining why valuation can be useful and also explaining the problems associated with trying to put a monetary value on environmental services that currently have no price in the market.

9.2 The main reason for trying to put a monetary value on degradation is to answer the question, How much does it matter? Some answers to this question can come from traditional environmental statistics. They can show the quantitative size of air emissions, for example, and even set these in context, as explored in chapters III - VI. They can show whether degradation is getting worse or not and if it is, whether it is getting worse at a faster rate. However, if the question How much does it matter? is to be followed by What shall we do about it? It is desirable to have answers to the supplementary questions, How much harm does it do? and What would it cost to avoid it?.

9.3 These supplementary questions lead one into the area of cost benefit analysis and the problems that arise when those causing the polluting and those suffering the consequences are not the same. This subject is also discussed in the first subsection below.

9.4 The whole issue of placing a notional valuation on degradation when no such valuation is actually observed in the economy raises important questions about how far a statistical system can account for hypothetical costs and prices. A discussion of these implications for the whole accounting system are postponed until chapter X.

2. Why value degradation?

9.5 Most of the interest in degradation concerns the impacts of pollution in air and water. In many countries now, even some that are resource-rich but economically poor, the problems of degradation are seen as being much more pressing than those of depletion. Chapter III discussed how these impacts could be measured in physical terms. Often, the physical data is more robust and may be seen to be more precise than monetary values. However, when decisions have to be made about restricting the amount of emissions to be permitted, the question how much it will cost inevitably arises. It is a particular problem when externalities are concerned because those who bear the costs of avoiding pollution are not necessarily those who benefit. There is thus a question how far the former can be obliged to incur costs to benefit the latter or how far the latter should bear damages to benefit the former.

9.6 Physical data sets are necessary to reveal the detailed processes taking place with respect to natural resources and environmental assets and are therefore essential for monitoring the progress of regulatory or conservation policies and for modelling the impacts of proposed policies or actions. Monetary data sets invoke valuation as, ideally, the means to allow "unpriced" goods and services to be compared with goods and services that have a market value. Valuation also permits the aggregation of different environmental goods and services, allows costs and benefits to be compared, and supports the internalization of externalities into monetary accounting. Monetary estimates can provide a common numeraire essential for comparison across different activities or products and permit decisions that necessarily involve trade-offs between alternative policies. This involves choices between alternative environmental goals as well between environmental and non-environmental objectives.

9.7 Many of the effects of environmental pollution are specific to a particular location (for example, a busy multilevel motorway intersection) or to a specific industry (for example, crop damage caused by acid rain) and may be caused by particular emissions rather than by their totality. Thus integrated environmental economic accounting involving valuation may be useful in these specific instances as part of project evaluation quite apart from any use of valuation techniques to derive macroeconomic aggregates.

3. Valuing costs and damages

9.8 Degradation causes damages and costs would need to be incurred either to prevent the damage or to rectify the harm caused. These questions lie at the heart of project appraisal where it is usual to consider a project's costs and benefits and to proceed only if the benefits are at least as great as the costs. This approach can be modified so that, instead of observing the price of a product, we can try to estimate the impact on the price of internalizing the costs to producers that would permit them to reduce or eliminate the generation of residuals and thus avoid the decline in welfare that degradation causes. Alternatively, instead of measuring benefits, we might measure the damages caused by residuals as if they were a sort of negative benefit.

9.9 In standard cost-benefit analysis, though, the costs and benefits accrue to the same unit which can assess whether to proceed with the project or not, independently of the decisions to be made by other units. The problem with environmental degradation is that not only are we concerned with disbenefits, or damages, rather than positive benefit, but these damages affect units other than the unit causing the damage. The disconnection between costs and damages where there is no penalty applied to the unit causing the damage gives rise to what economists refer to as externalities.

9.10 The damages take the form of negative externalities associated with production and consumption. Negative externalities are assumed to give rise to inefficiencies because the unpriced components or characteristics of the environment will be overexploited, leading to social costs that are higher than the private benefits derived from this overexploitation. Conversely, positive externalities may arise (for example, from carbon sequestration by managed forests) where the social benefits will be higher than the private benefits.

9.11 In general, just as a unit will undertake a project if the benefits are at least as great as the costs, so it will incur costs to avoid damages of a greater value. While there is no equality between costs and benefits or damages, for a single unit operating rationally there would be no case where damages would persist if the cost of avoiding them was less than the value of the damage. When the damage is felt to be an externality, though, it is no longer the case that the damage is likely to be avoided even if it is greatly in excess of the costs of avoiding it.

9.12 A comparison of costs and benefits is of particular use to government as policy maker. If there seems to be a compelling case for imposing costs on polluting units for the general benefit that will result, government may wish to bring in legislation to enforce such action. Increasingly, as discussed in chapter VI, there is a move away from environmental protection by means of legislation towards the use of market instruments, either taxes or licences such as emissions permits. This gives the polluter an incentive to find ways to reduce pollution and thus reduce tax payments or to realize the value of the permit by selling it to another unit that has not yet reduced its pollution levels.

4. What is being valued?

9.13 It is important to note that trying to put a value on environmental degradation is not the same as trying to value environmental media. Traditionally, air and water were held to be free gifts of nature. Not only is a shortage of water in the strict quantitative sense now a real threat, but the quality of air and water deteriorates as economic production generates more residuals than can be absorbed by natural assimilation. If a product is so abundant that no amount of demand causes a scarcity of the product, the product has no price attached to it and is freely available to all who demand it. When a product is scarce, demand exceeds supply and, in consequence, the price will rise; when supply exceeds demand and the product is less scarce, the price will fall. The "product" we are trying to value here is clean rather than contaminated environmental media. The task is thus to attribute a notional value to the decline in the quality rather than in the quantity of a resource.

9.14 Another way of considering what it is we are valuing is to reconsider the notion of environmental function first introduced in chapter I. These functions can be thought of as falling into three categories: resource functions whereby the environment provides materials that are taken into the economy and transformed into produced goods and services; sink functions whereby residuals generated by production are emitted to the environmental media of air, water and land for assimilation; and service functions which can be further subdivided into survival functions and amenity functions. What we are doing, therefore, is to try to find a way to value reductions in the sink and service functions provided by the environment.

5. Problems with valuing degradation

9.15 Chapters VII and VIII discussed how valuations relating to certain environmental assets could be determined even though they appear to be free gifts of nature. This depended on the fact that the assets in question (timber, minerals, fish etc.) are absorbed into the goods and services that are produced in the economy. The method involved was essentially one of dividing the income derived in the production process into one part attributable to natural resources and another part due entirely to human endeavour.

9.16 Degradation cannot be valued in this way. There is no point in trying to put a value on a cubic metre of clean air or clean sea water, if only because there is no useful corresponding total volume. While we might desire to value the services or functions provided by environmental media, this is generally not possible. Instead, as explained above, we must concentrate on the costs involved in combating residual generation or the damages incurred when such generation takes place.

9.17 These costs actually incurred to avoid pollution and those incurred to remedy damages caused by pollution are captured in the standard national accounts. These are described in chapter V and are referred to again briefly in this chapter. Knowledge of these actual costs is instrumental in placing a value on the pollution not avoided and the non-remedied damage incurred. Further, for some analyses, it may be useful to aggregate both the actual costs and the potential costs necessary to reach a certain environmental standard.

9.18 Degradation is seldom an absolute condition. It is difficult to imagine an economy as we know it functioning without some contamination of environmental media. The problem is whether the degree of contamination is "excessive" according to some norm. The most rigorous enjoins is that it should not exceed the natural assimilation properties of the media, but in practice less rigid norms are specified, for example, the level of emission-generation agreed under the Kyoto Protocol to the United Nations Framework Convention on Climate Change (United Nations, 1997b) to be currently "acceptable". The value to be placed on degradation will vary with the environmental standards taken as goals.

9.19 This is where the above discussion on the value of costs and damages becomes relevant. There is no assurance that the cost-based and damage-based estimates will be equal because the market mechanism to juxtapose them is missing, but either or both approaches may be used depending on the focus of interest.

9.20 Unfortunately, given the lack of information and the scientific and other uncertainty often associated with environmental issues, the valuation of both the costs and benefits of environmental issues is frequently difficult, if not impossible. Usually in these cases, only the costs, and not the benefits, of a given policy can be determined with any confidence, as the policy will typically involve easily identifiable costs of marketplace materials, capital and labour. The benefits, however, refer to improvements, additions or prevention of damage to natural resources and environmental assets and thus to the value of the assets that frequently do not have observable market prices. The lack of a market in these assets means that not only are there no prices, but there is no mechanism for confronting the costs and benefits. Prioritization must therefore occur through some other medium.

9.21 One means depends on the political process itself to reveal a ranking of concerns. However the ranking is established, once it is done, the appropriate response may be determined through analysis so as to identify the most cost-efficient policies that will address a pre-specified priority and link it to a pre-specified standard of success. The advantage of this approach over cost-benefit analysis is that it requires monetary valuation not of the natural resource or environmental asset itself, but of the proposed responses. These proposed responses may also involve environmental costs that cannot be easily measured; again, the political process may suggest whether these costs exceed the benefits and whether the activity should be undertaken.

9.22 Ambitious as these approaches are, they are still limited in some respects. Typically, only some costs and damages will be estimated. Because the links between residuals and damages are not perfectly understood, even attempts to cover the same problems under both methods may fail. Some problems may be amenable to easier measurement by one technique rather than another. Neither approach will give a full estimate of the value of environmental services, resource by resource, nor is either intended to do so. That is a task for the future. However, notwithstanding all these caveats, progress on the application of both cost-based and damage-based estimates of degradation can be reported.

6. Methods of valuing degradation

9.23 Most methods of valuing the prevention of degradation consist in combining information on the degree of emissions to be combated with the costs per unit of amelioration. These costs are not linear. Often initial, large improvements can be made at a much lower per unit cost than that necessary to cleanse the last unit of emission. Sometimes, the fact that it may be impossible to completely eliminate the last unit of pollutant implies an infinite cost. A similar pattern is observed for damage costs. The goal, therefore, is to derive cost and damage functions that relate costs and damages to varying levels of emissions and thus degradation.

Cost-based valuation methods

9.24 The information on emissions used in cost-based estimates typically comes from the sort of studies described in chapter III. Information on the costs of combating these emissions may come from the sort of information described in chapter V or from special studies.

9.25 There are three ways in which emissions can be controlled. Steps can be taken to avoid the emissions in the first place, either by refraining from the activity giving rise to the emissions or by substituting less damaging inputs and outputs. The second solution involves capturing the emissions and making them less harmful, for example, by installing scrubbers on processing equipment. The third option is to restore the environment by means of clean-up activities.

9.26 The pricing options and methods of applying these alternatives are described in section B.

Damage-based valuation methods

9.27 Damage-based valuation methods are based on two sets of information not discussed in earlier chapters. The first is to assess the extent of the damage that has occurred. The damage of most immediate concern to many observers is the damage caused to health by pollution. To assess this damage, use is made of so-called dose-response functions. This technique, which is discussed in section C, correlates the existence of a pollutant with the "receptors" of another parameter, in this case, specifically, different types of illness.

9.28 Once the extent of the damage is established, it is necessary to find a way of placing a monetary valuation on it. To a certain extent, some of the pricing methods used for cost-based valuation can be used but, more commonly, alternative valuation methods are employed. Each can be seen as a measure of the respondents' "willingness to pay" for a given service. Market prices are characterized as a directly revealed willingness to pay. Various econometric techniques can be used in connection with observed pricing behaviour to determine willingness to pay indirectly. Alternatively, and more controversially, surveys of stated willingness to pay can be undertaken and used.

9.29 The method of "benefits transfer" should also be considered. Benefits transfer is a method used to estimate economic values for ecosystem services by transferring available valuation information from studies already completed in another location and/or context. In other words, benefits transfer is not a separate valuation method, but one involving an estimate of benefits for one context by adapting an estimate of benefits from some other context.

9.30 These pricing alternatives and their applications are described in section C.

7. Degradation crossing time and space

9.31 There is a time dimension in degradation occurrence and remediation which needs to be recognized. Degradation that occurs in one period and is not remedied by either natural or man-made processes carries forward to the next period. This accumulation is referred to as environmental debt and may affect the rate at which natural assimilation of waste will occur in future periods. Should values of degradation apply only to the amount of emissions generated in the period in question or should they cover environmental debt also? If the latter, should it be assumed that the debt is to be cleared in a single period or over a number of years?

9.32 There is a further problem with applying pricing assumptions in either cost-based or damage-based estimates and that is that the assumptions involved are not always - indeed, are usually not - strictly conformable with the assumptions built into economic accounting. Another problem of concern is that emissions in one country may cause damages not just in that country but also in another country. Approaches to both these problems are presented in section D.

8. Status and future work on valuing degradation

9.33 The techniques described in this chapter are still being developed and the data requirements for implementing them are both extensive and resource-intensive and thus generally incomplete. Such work therefore should be seen as being in its early stages and liable to change, perhaps radically, in the medium term; in its present state, it may be applied to valuation in special contexts, for example, analysis of the costs of a toxic waste site or the impact economy-wide of particular emissions. However, although these techniques are not sufficiently well developed to enable a monetary value to be put on biodiversity or the threats from global warming, it should be noted that the threats posed by these phenomena may not be capable of further illumination by monetary valuation.

9.34 Section E provides an assessment of the suitability of the pricing techniques discussed in sections B and C as well as comments on methodological reservations and data limitations.

B. Cost-based pricing techniques

9.35 There are only a limited number of ways of dealing with environmental degradation. One can try to prevent it before it happens or try to reverse it once it has happened. These two alternatives, referred to as avoidance and restoration, respectively, can be further elaborated, for example, in the taxonomy of pricing methods for cost-based estimates as shown in Box 9.1. These methods are discussed below. The term "maintenance cost" was used in the 1993 SEEA generically to encompass cost-based methods; it is convenient to preserve this usage, since it is evocative of the underlying principle of maintaining environmental functions.

Box 9.1. Taxonomy of cost-based estimates

Avoidance costs
Structural adjustment costs
- Reduction of activities or complete abstention
- Changes in production and consumption patterns

Abatement costs
- Input substitution and changes in technology to achieve the same output
- Treatment costs (end-of-pipe, safe disposal etc.)

Restoration costs

1. Structural adjustment costs

9.36 These costs can normally be estimated only by modelling or by assumption. They are therefore discussed in section D which deals with modelling approaches. It should be noted, however, that in some cases, structural adjustment may be a highly cost-effective way to achieve considerable savings on environmental pollution with little direct impact on gross domestic product (GDP).

2. Abatement costs

9.37 Imputed abatement costs refer to expenditures that reduce the direct pressures on natural assets (for example, from air emissions or waste disposal). Their calculation does not require the definition of absolute environmental quality levels or standards but of reductions in levels (for residual flows in particular). Ideally, imputed abatement costs should always be calculated as the sum of direct and indirect cost effects of additional prevention measures. The present section concentrates on the conceptual and empirical steps necessary for the calculation of direct abatement costs.

Conceptual considerations

9.38 Usually abatement cost data are collected on a microeconomic level and describe the costs of technical options for reducing a certain type of pollution. This is presented as cost functions (abatement cost curves). Such cost functions plot, for each type of measure, the cost per unit of avoided pollutant against the volume of avoided pollutants. In practice, such curves often confirm the standard economic assumption of increasing marginal costs. Exceptions, however, often exist. In studies of CO_2 abatement costs, it is often found that substantial initial reductions can be obtained at negative costs, for instance, by implementing energy saving measures that are actually profitable. It should also be noted that abatement cost curves are not stable over time. Ideally, they reflect the technological possibilities and knowledge available in a given accounting year. Costs will tend to decrease over time with technological progress and rate of application of techniques (economies of scale) so that the cost data need to be updated regularly.

9.39 Once a marginal abatement cost curve is developed, it may be used to help determine the targets to be set for environmental standards. Alternatively, total abatement costs can be derived from cost functions by combining them with given environmental standards or targets, for example, a certain reduction of annual CO_2 emissions. Abatement costs can be calculated for a single pollutant, for a set of pollutants contributing to a certain environmental problem or theme, or even jointly for all environmental problems. Obviously, the complexity of the cost calculation increases as the extent of the environmental concern widens.

9.40 The additional costs incurred to implement technical measures for one statistical unit are defined as direct costs. This is the extent to which the costs can be captured in the maintenance cost approach. If the measures were applied (hypothetically) to a whole industry, this would immediately affect the cost structure, the prices and level of output of this industry. In many cases a broader economy-wide application of such measures is necessary to achieve given environmental targets (CO_2 reduction, reduction of air pollution in general, reductions in the amounts of solid waste generated, changes in agricultural practices etc.). The fact that this influences the structure of output and intermediate consumption of many industries, leads to changes in the structure of prices throughout the economy. These measures cover both direct and indirect costs, both of which are captured in the modelling approaches to be discussed in chapter X.

Data considerations

9.41 Three types of data are required:

(a) Data on emissions by economic activities and underlying production processes disaggregated according to technical characteristics;

(b) Parameters of available abatement techniques/measures (for example, reduction potential, actual rate of application for each production process/economic activity);

(c) Cost data for these measures.

9.42 The physical data underlying cost-based calculations will very often come from the sorts of analyses described at length in chapter III where use is made of emission data and technical abatement data often originating from technology-oriented databases. Such databases may be held by research institutes but, increasingly, they are being held also by Governments for regulatory purposes, for example, for prescription of best available technologies (BAT). These databases use technical classifications and therefore need to be converted to the standard industrial classification to be used in conjunction with the economic data.

9.43 Abatement cost calculations are based on pressures imposed by economic activities on the environment of a single country and in a single year. Pressures mostly comprise discharges of different kinds of residuals but may include land use and quantitative use of natural assets as well.

9.44 Cost data for abatement measures are available on a microeconomic level relating to a particular technology or process, that is, they may relate to a sub-establishment process. Aggregation is needed to establish abatement cost curves at the level of the sector and for economy-wide indicators, but this is not just a question of straightforward aggregation for the reasons described above. Consequently, the accounting of abatement costs is different for the microeconomic (individual economic agents and establishments), the meso-economic (industries and homogeneous branches of production, and groupings thereof) and the macroeconomic accounting levels.

Practical aspects/limitations of the method

9.45 In order to obtain the total costs of technical measures including both direct and indirect costs, a modelling approach is necessary. Normally this will have an input-output core and will be closely linked with direct cost calculations.

9.46 Direct abatement-cost calculations should take account of interactions between technical abatement measures, interactions between pollutants, incompatibility of abatement measures and the uncertainties of measurement of integrated techniques. Such problems are very rarely covered in primary data sources.

9.47 It is not always easy to distinguish between costs for environmental protection and other costs. For example, is end-of-pipe technology entirely a cost for environmental protection? Even when the cost for energy-saving technology aimed at reducing CO_2 emissions is deemed to be entirely a cost for environmental protection, questions still remain. When new vehicle engines reduce NO_X and CO_2 emissions but also increase energy efficiency and generate more power, it is difficult to specify the portion of the greater engine cost due to environmental protection. This issue of allocation is addressed in detail in chapter V for actual expenditure.

9.48 It is important to note that cost estimates do not represent the value of the damage caused by the additional environmental deterioration, that is to say, the size of the value obtained by the cost-based method does not represent the severity of environmental problems; rather, it represents the effort, in terms of costs, of taking measures to rectify the environmental problems. Measuring the severity of the problem depends on an assessment of the significance of the environmental function affected. For example, drinking water may be "cleaner" than river water but may pose a severer problem if it is not potable than river water that poses no threat to river life or (human) swimmers. It is particularly important to note the problems of scale and non-linearity in this respect. Significantly large reductions in damage may be achievable through treatment and restoration at reasonable cost with very large associated benefits. However, the cost for the last few percentages of damage may be very much greater or even infinitely expensive even though little extra benefit results.

Use in national accounts

9.49 The concept of costs is used in the present section in the same way as that of the costs of production in national accounts. These should include costs of both labour and capital as well as intermediate costs. Theoretically, marginal costs (and benefits) should be used for valuation. However, in practice such marginal costs are often very difficult to determine. When direct information on costs and prices is not available to national accountants, they may need to have recourse to using average costs and prices. A similar process is used in estimating environmental costs. This approximation, however, reflects the assumption that there are no economies of scale in production, which may be true occasionally but not in general. The dangers of using average coefficients as if they were marginal should be kept in mind in environmental (and economic) analysis, especially when the calculations are based on input-output coefficients.[32]

3. Restoration costs

9.50 Some restoration costs are (or should be) implicit in costs associated with other assets, for example, the costs to decommission nuclear power stations and rehabilitate agricultural land. The appropriate treatment of these is discussed in chapter VI. They are assumed to be "actual" costs in the sense that they can be accounted for directly even if they have not yet been incurred. The costs of concern here are restoration costs that have no such association with SNA assets and are not accounted for elsewhere. An obvious example involves the restoration of contaminated water bodies.

9.51 Hypothetical restoration costs are one of the categories of the costs for present environmental deterioration. They are used in cost-based estimates only if they are the "least-cost option". The hypothetical costs of restoring the environment to defined standards are important outside the national accounting framework. They include the mitigation/abatement of accumulated damage required to return to those standards.

C. Damage- and benefit-based pricing techniques

9.52 The previous section described how to estimate the costs of maintaining an adequate standard of environmental functions in terms of the quality of the environmental media used as sinks. The present section looks at the consequences of overusing environmental sinks in terms of the damage caused by this overuse. Sometimes the damage caused can be priced directly, in the case, for example, of estimating the cost of cleaning a building blackened by atmospheric pollution. For other damages, including the highly significant damage to human health, it is necessary first to make an estimate of the damage and then to find suitable prices to apply to this quantification so as to obtain a total damage-based estimate of the type of degradation being studied.

9.53 The pricing techniques to be described are all based on an assessment of what the unit suffering from the effects of the overuse of environmental sinks would be willing to pay to be free of those effects. This can also be interpreted as the price of an environmental service or, broadly, of environmental quality. Prices that are observed in the economy and used in the national accounts reflect the minimum amount that the purchaser is prepared to pay to acquire a given product. This concept of "willingness to pay" is carried over to services that are not currently priced.

9.54 Two broad approaches are available to estimating willingness to pay. The first is to observe it directly or estimate it indirectly using statistical or econometric techniques. These are known as revealed preference methods. The second approach encompasses methods of asking people to state their preferences, which methods can also be direct or indirect. A taxonomy of these different methods is given in Box 9.2. Each of the two main groups of valuation techniques is discussed below after considering how damage is quantified.

[32] Average environmental costs do approximate marginal costs and benefits under certain conditions (see Bartelmus (1998), pp. 290-291).

1. Estimating the damage done

9.55 The task is to translate residual generation, as described in chapter III, into monetary estimates of particular forms of damage. In order to do this, a sequence of steps, sometimes referred to as the "impact pathway", must be followed.

9.56 The first step is to apply a physical transmission model to see how residual generation affects ambient concentrations of the pollutant in question. Only after this is related to physical damage done can valuation techniques be applied. In making the conversion from domestic generation to domestic ambient concentration, allowance must be made, where appropriate, for the effect of imports and exports of residuals.

Box 9.2. Taxonomy of benefit/damage valuation techniques

Revealed preferences
- Direct
  - Market prices
- Indirect
  - Hedonic price analysis
  - Travel cost method

Stated preferences
- Direct
  - Contingent valuation
- Indirect
  - Conjoint analysis

9.57 One technique taking the step of translating from ambient concentration to damage entails use of the dose-response function (described below), where the ambient concentration is treated as the "dose" and the physical damage resulting therefrom as the "response".

Dose-response functions

9.58 Dose-response (or, more specifically, exposure-response) functions measure the relationship between exposure to pollution as cause and specific outcomes as effect. They refer to damages/production losses incurred in the current year, regardless of when the pollution occured. A mathematical relationship is established which relates how much a certain amount of pollution impacts on production, capital, ecosystems, human health etc. By relating a specific measure of an environmental impact to a measure of pollution exposure, while controlling for other factors, the role of pollution in causing the environmental impact can be estimated. This estimate can then be used to predict the environmental improvement (deterioration) corresponding to a decrease (increase) in exposure.

9.59 Dose-response functions assume a variety of forms, which may be linear or non-linear and may or may not exhibit thresholds (levels of exposure above which damages increase sharply). For example, those describing the effects of various air pollutants on agriculture have proved to be particularly complex with their incorporation of both positive and negative effects, because of the potential for certain pollutants (for example, those containing sulphur and nitrogen) to act as fertilizers. Ideally, these functions and other models, instead of relying on simulations, are derived from epidemiological studies of the observed effects of pollutants on actual populations of people, crops etc.

Derivation of dose-response functions

9.60 The key issues relating to the use of dose-response functions can be clearly illustrated by considering the linkages between air quality and health impacts. For example, a large number of studies have focused on the acute mortality effects of exposure to particulates of less than 10 microns in aerodynamic diameter (PM_{10}). A single study that find a significant association between a health effect and a specific air pollutant does not prove causality; however, it is the number of studies that is important, since the inference of causation is strengthened if epidemiological results are duplicated across several studies. One approach for reducing the uncertainty associated with individual studies is to use meta-analytical techniques that, on the basis of the statistical pooling and aggregating of results from several studies, produce a "best estimate" of a causal relationship that is less uncertain.

9.61 The reported epidemiological studies involve two principal study designs, time-series and cross-sectional. The more common time series studies correlate daily variations in air pollution with variation in daily mortality in a given city. The advantage of these studies is that they do not have to control for a large number of "confounding factors", since the population characteristics (age, smoking, occupational exposure, health habits etc.) are essentially unchanged.

9.62 A cross-sectional analysis compares differences in health outcomes across several locations at a selected point or period of time and, in principle, captures both acute and chronic effects of particulate pollution. The common concern about these studies is whether potential omitted and confounding variables such as those mentioned above have been adequately controlled for. For example, although individuals may be affected by a combination of pollutants, the presence of other pollutants may not be incorporated into the study owing to the limited availability of pollution data. In cohort studies, in which a population sample is selected and followed over time, these types of problems are avoided but they are expensive and therefore not often carried out.

9.63 One meta-analysis of the results of a number of studies (Commission of the European Communities, 1999) presents an average percentage change in average mortality per microgram per cubic metre ($\mu g/m^3$) change in PM_{10} of 0.040. In other words, the dose-response function relating the increase in mortality to PM_{10} is generated by the following equation:

Change in mortality rates = 0.040 *multiplied by* change in PM_{10} concentration

The total physical impact of a change in PM_{10} concentration therefore depends on the size of the population exposed to the concentration change and the change in the mortality rate of the population.

Coverage

9.64 The vast majority of work on the estimation of dose-response functions has been in relation to the impacts of ambient air quality on health, materials and agricultural crops. These are the impacts that can currently be quantified with the greatest confidence. To a lesser extent, the impact of air quality on forests and the impact of noise on amenity have also been quantified with a reasonable degree of confidence. These dose-response functions were surveyed by the Commission of the European Communities (1999 and 2000) which applied them to the assessment of environmental damage costs from energy and transport across EU.

9.65 In other environmental media, the evidence is less certain and subject to a greater variation in dispersion patterns and confounding factors. To give a simple example, in the case of water pollution, the estimation is complicated by the fact that human health is affected less by ambient water quality than by access to clean drinking water and adequate sanitation and by the household's level of income and education. Surveys of the derivation of dose-response functions relating water pollution to health impacts are given in Fleisher and others (1998) and Preuss (1998).

Applications

9.66 The use of dose-response functions in environmental accounting practices primarily relates to the application of part, or whole, of the impact-pathway methodology, which traces quantitatively the consequences of pollutant emissions, from increased ambient concentrations to ultimate environmental impacts.

9.67 An estimation of the physical environmental impact may then be converted to monetary terms (provided there are valuation data available) to give an estimate of the value of environmental damage. A large-scale application of this methodology has recently been made in the Green Accounting Research Projects (GARP), specifically, GARP-I (Markandya and Pavan, 1999) and GARP-II (Commission of the European Communities, 1999), where the value of damage was assigned to economic sectors in the United Kingdom of Great Britain and Northern Ireland, Germany, Italy and the Netherlands. More generally, knowledge of the dose-response function for any specific environmental damage being considered in a policy-making process is valuable, since it indicates the degree to which a polluter must modify its activities to reduce environmental damage to a socially acceptable level. Monetization of the costs and benefits of changes in emissions further informs environmental policy analysis.

Main results of the GARP project

9.68 Damages have been measured and attributed for impacts of sulphur dioxide, particulate matter and ozone on human health, crops and building materials for Germany, the Netherlands, Italy and the United Kingdom, health damages representing the largest share of impacts.

9.69 Other important results include the assessment of the effects of different industrial sectors on water pollutant levels in Italy and Germany. These results are useful in targeting policies more effectively towards the most polluting industries and the most damaging pollutants (Markandya and Tamborra, 2001).

Transfer of dose-response functions

9.70 Recently, dose-response functions estimated for one country have been applied to populations lacking their own epidemiological studies in order to estimate the effects of exposure to pollution. Although this practice does provide a rough estimate of the environmental effects in previously unstudied countries, it should be applied with caution.

9.71 Without further testing, there is no reason to believe that the dose-response relationship calculated for one area will be exactly the same as that for another. In the case of the air pollution-health context outlined above, differences in the composition of air pollution, in the age distribution of the population, in access to and quality of medical care, in baseline health and education and in other behavioural and socio-economic variables all may cause variations in the response to air pollution.

9.72 Despite these constraints, it may often be sensible to provide some indication of the types of functional relationships to be expected in the context considered, with appropriate caveats describing the uncertainties inherent in such a transfer process.

Conclusions and outlook for future use

9.73 The estimation of dose-response functions has, in recent years, dramatically improved the quantification of environmental damages from a given pollution concentration, particularly in relation to air pollution. Confounding factors are more difficult to control for in deriving dose-response functions for water- and land-based pollution, though some relationships have been estimated.

9.74 Uncertainty in the robustness of existing dose-response functions remains. However, with increased awareness of the impacts of pollution on human health in particular and a need to justify policy actions in cost-benefit and sustainability terms, it is likely that further research will refine these functions and reduce the need for function transfer between contexts.

2. Revealed-preference pricing techniques

9.75 The values of some environmental goods or services can be measured using market prices. Some natural resources, such as fish or wood, are traded in markets. There was discussion in chapters VII and VIII about how a value for these environmental goods can be determined.

9.76 Some ecosystem services, like aesthetic views or many recreational experiences, may not be directly bought and sold in markets; however, the prices people are willing to pay in markets for related goods can be used to estimate their values. For example, people often pay a higher price for a home with a view of the ocean or will take the time to travel to a special spot for fishing or bird watching. This revealed preference for environmental services can be used as a proxy for the economic or market value of the view or the recreational experience. The methods that use revealed preferences include market valuation of economic losses, hedonic pricing methods and travel cost methods.

Market prices

9.77 The market price method is limited in its applicability, since much environmental damage cannot be associated with a marketed good directly.

9.78 The effects of environmental damage on a fixed asset may be such that its useful life is foreshortened or that the asset is less effective than previously. This will result in a fall in the price of the asset which can, in principle, be attributed to environmental damage. However, if the national accounts calculations allow for the effect of environmental damage on the service life of the asset, this effect will have already been captured in the measures of consumption of fixed capital and should not be double-counted by allowing for it again as environmental damage.

9.79 Similarly, if falling soil quality leads to falling agricultural production, the decrease in the current year will have been allowed for in the measure of agricultural output and should not be deducted a second time. There will be an element to be deducted to allow for the effect of soil degradation on the land value. Following the discussion in chapter VII, this decrease will show the fall in the net present value of the agricultural yield expected in future years.

9.80 There are some cases where maintenance cost techniques may also be appropriate in the damage-based approach. Knowing the cost of restoring some items, an estimate can be made for similar items that have been damaged but not restored or replaced. Some avoidance costs such as the purchase of water purifiers, noise insulation and the like can be considered a form of defensive or preventive expenditures. At the limit, the amount spent on such items shows how much consumers are willing to pay to avoid the damage or nuisance in the first place.

9.81 Market valuation of economic losses reflects the economic effects of environmental damage but does not include impacts on well-being. Estimates of these impacts would require supplementary information.

Hedonic pricing

9.82 The hedonic pricing method is based on the idea that the market value of goods depends on a number of separately identified characteristics. This dependence can be established analytically. It is a technique increasingly being used to measure the price indices of goods such as computers where the technical specifications change very quickly and it is desirable to isolate the technological effect from the general price effect. The idea can be applied to areas where environmental factors influence prices in order to quantify these effects separately from others.

9.83 Good examples are land and houses. Property values reflect a variety of different attributes - both non-environmental properties such as room numbers and sizes, proximity to work or access to transport and other infrastructures; and environmental properties, such as noise levels from road and airports, the surrounding landscapes and so on. Given data on a sufficient number of properties where these characteristics have been identified, it is possible to derive estimates of how much of the price is due to each of the effects. The price effect of the environmental factors can then be taken as a proxy for the market price of the environmental service that they represent.

9.84 Similarly, the technique can be applied to wage rates in different industries to take account of such occupational factors as noise, air pollution and the risk of fatal injuries.

9.85 The method requires large amounts of good-quality data where all the relevant characteristics are enumerated, and a high degree of statistical expertise, since the results depend heavily on model specification (see, for example, Braden and Kolstad, 1991).

Travel cost method

9.86 The travel cost method seeks to estimate a money value on the basis of the amount that people actually pay (in money and time) to gain access to beautiful sites, wilderness and so on, or to avoid various forms of damage and degradation. The costs incurred by visitors to a site are used to determine a demand curve for the recreational value that they place upon that site. This can be the basis for estimates of the value of the site, and hence of the significance in monetary terms of benefit or damage to or loss of availability of the site.

9.87 There are typically three components of the “travel costs” that can be directly observed: the direct travel costs such as fuel costs, entrance fees where they exist, and the time costs to the individuals understood as the opportunities that have been forgone in using their time to go to the site. The number of visits an individual will make to a site will be a function of such factors as the distance to the site, The accessibility of the site by road, the income of the respondents, and the alternative sites available. Cost data can be estimated for different zones around the site. Data on visiting frequencies are in some instances readily available, or might otherwise be estimated through surveys at the site. Statistical methods are used to plot the relationship between travel and time costs and the number of visits made to the site, from which it is possible to calculate an average value per visit. This is subsequently employed to calculate a monetary value for the recreational value of the site.

9.88 To value a change in the environmental quality of the site, the value of the site after the change must be re-estimated. The change in the number of visitors will be an important factor in this but not the only one, as the value of the visit could also have changed.

9.89 The quality of the results from this method depends on the validity of the assumptions made in deriving them. Some studies involve multiple variables, allowing for substitute sites, multiple sites visited and time spent on site. The most difficult variable to quantify is the opportunity cost of the time spent getting to and from the site. Further, measuring recreational quality, and relating it to environmental quality can be difficult. The method is limited in scope, since it can be used to value only recreational land and watercourses (with public access).

3. Stated preferences

9.90 Many ecosystem services are not traded in markets, and are not closely related to any marketed goods. Thus, people cannot "reveal" what they are willing to pay for these services through market purchases or actions. In these cases, surveys can be used to ask people directly what they are willing to pay, based on a hypothetical scenario. Alternatively, people can be asked to make trade-offs among different alternatives; based on these, their willingness to pay can be estimated. These methods include contingent valuation which is a direct method and conjoint analysis approaches (contingent ranking, rating etc.) which are indirect. Both generate welfare estimates of environmental benefits/damages based on stated willingness to pay. The methods are referred to as "stated preference" methods, because, instead of inferring values from actual choices as the "revealed preference" methods do, they ask people to state their values directly.

9.91 Stated preference techniques, unlike revealed preference techniques, can elicit information about both use and non-use values (see, for example, Mitchell and Carson, 1989). This can be a strength when the desired measure is well-being or welfare. On the other hand, there is continued scepticism about the worth of hypothetical assertions of willingness to pay, though recently there has been growing respect for such techniques, at least in academic circles.

Contingent valuation

9.92 The contingent valuation method presents, to a representative sample of the relevant population, hypothetical situations that are designed to elicit statements about how much they would be willing to pay for specific environmental services. In some cases, people are asked for the amount of compensation they would be willing to accept for giving up specific environmental services. Contingent valuation studies can be conducted as in-person or telephone interviews or mail surveys. The method is called "contingent" valuation, because people are asked to state their willingness to pay, contingent on a specific hypothetical scenario and description of the environmental service. Respondents may be asked questions with only yes or no answers (such as, Would you pay X for the following service?) or more open-ended questions allowing them to name their own figure. This method, in its various forms, can be applied for a broad range of environmental questions.

9.93 The results of contingent valuation surveys often reflect the fact that people are highly sensitive to what they believe they are being asked to value, as well as the context that is described in the survey. Thus, it is essential for contingent valuation researchers to clearly define the services and the context, and to demonstrate that respondents are actually stating their values for these services when they answer the valuation questions.

9.94 Application of contingent valuation methods received a strong boost through emergence of legal frameworks, notably in the United States of America, where these arose the question (among others) of the role of contingent valuation estimations for defining compensation for damages such as those resulting from the 1989 Exxon Valdez oil tanker wreck in Alaska. A United States panel of renowned economists, referred to as the National Oceanic and Atmospheric Administration (NOAA) Panel, chaired by Kenneth Arrow and Robert Solow, was appointed to examine the issue. Its report concluded that:

> "contingent valuation studies can produce estimates reliable enough to be the starting point for a judicial or administrative determination of natural resources damages–including lost passive use" (Arrow and others, 1993).

9.95 The Panel suggested guidelines to help ensure the reliability of contingent valuation surveys on passive use values including the use of in-person interviews, a binary discrete choice question, a careful description of the good and its substitutes, and the inclusion of several different tests in the report on survey results.

9.96 The approach adopted by the NOAA Panel was generally conservative, advocating those procedures that tended to produce modest environmental damage valuations. The report included recommendations on how to eliminate "extreme" responses and expressed a preference for willingness-to-pay formats over willingness-to-accept formats, since the latter generally resulted in higher values. Other recommendations included attention to the importance of an accurate description of policies or programmes, information about alternative undamaged "substitute" sites available and the opportunity costs involved, follow-up questions to discover reasons for apparently discrepant replies to willingness-to-pay questions, procedures for the elimination of "illegitimate" bids and so on.

9.97 A number of possible sources of bias are often cited in contingent valuation studies including:

(a) Strategic and protest bids: individuals can understate (free riders), overstate (strategic bidding) or put forth a zero or very large bid because they do not accept the contingent valuation method itself (protest bidding);

(b) Design effects: the way a bid is elicited can affect the outcome, and different elicitation formats will produce different results;

(c) Presentation and information effects: generally, the better the information and its presentation, the higher the bid;

(d) Payment vehicle biases: the popularity or unpopularity of taxes has a strong influence on willingness-to-pay bids, while willingness-to pay into a private trust fund can be affected by the perceived trustworthiness of the fund;

(e) Embedding and part/whole effects: respondents to willingness-to-pay surveys are apt to bid in almost the same way for the preservation of watering sites for 2,000 migratory birds as they would for 200,000 (Desvouges and others, 1993) or to bid in the same way for cleaning lakes in one part of a region as for cleaning them in the whole region (Kahneman and Knetsch, 1992). Similar embedding effects can be arrived at by altering the payment periods for the goods in question;

(f) Ordering effects: the order in which options are presented to the individual can affect the payments;

(g) Framing effects: the way options are framed can change the response;

(h) Compliance bias: individuals may respond as they do in an attempt to please the interviewer.

9.98 In the absence of any real market for the goods or damages for which they are attempting to infer values, and given the speculative character of projections into the future, it is difficult to demonstrate that contingent valuation studies establish "correct" prices, for example, prices consistent with allocative efficiency. One validation test entails comparing results from different elicitation procedures to see if they converge towards the same results. However, results from comparisons of contingent valuation, hedonic and travel-time measures are mixed; and, in any case, the validity of the comparison depends on the exact parameters of the investigation. Another form of validation, which entails concentrating on the internal consistency of the method, involves trying to eliminate sources of ambiguity or "bias" that distort the discovery of the "correct" value for the good or amenity in question. It can also involve inferring the underlying meanings and determinants of people's responses through statistical or sociological analyses.

Willingness to pay and consumer surplus

9.99 No one is constrained to buy particular goods and services in the economy. Notionally, each consumer may have a list of the prices he or she is prepared to pay for each of the goods and services desired. Assuming for the sake of simplicity that there is no budget constraint, the individual will purchase those goods and services whose prices are no higher than the matching willingness-to-pay figure. For many products, the prices will be lower than the maximum an individual would be prepared to pay. The difference between the price paid and the maximum an individual would pay is called the consumer surplus.

9.100 For any single good, there will be at least one purchaser who has no consumer surplus: he is paying the maximum he is willing to pay. Thus, the market price represents the willingness to pay only of the last, marginal consumer of the product. Other purchasers of the product will benefit from a degree of consumer surplus but the amount of this will vary with preferences and income levels. Consumer surplus is often identified with satisfaction or welfare, and, in this connection, we should note that it may also vary with the level of expenditure on the product in question. If one is very thirsty, the consumer surplus is very high from the first drink but falls as thirst is quenched.

9.101 One problem with the use of contingent valuation to value environmental damage is that it gives an average willingness-to-pay figure which includes an element of consumer surplus of indeterminate amount. This poses a problem when using contingent valuation in the accounting context, since the national accounts exclude consumer surplus. The absence of budget restrictions in the context of contingent valuation surveys may also lead to higher valuation levels than would be faced in fact and is another source of incompatibility with the national accounts.

Conjoint analysis approaches

9.102 In their recommendations for future research, the NOAA Panel referred to the "conjoint analysis" method which has been used in estimating the demand for highly innovative commercial products in the field of market research. The motivation was the fact that practitioners have found that survey methods are better at estimating relative demand than absolute demand.

9.103 Valuation methods based on conjoint analysis differ from contingent valuation because they do not ask people directly to state their values in monetary terms. Instead, values are inferred from the hypothetical choices or trade-offs that people make. The respondent is asked to state a preference for one group of environmental services or characteristics at a given price or cost to the individual over another group of environmental characteristics at a different price or cost. Conjoint analysis has been used as a designation for a number of related approaches where choices, ranks or matches between alternatives are involved (Hanemann and Kanninen, 1999).

9.104 There are a variety of formats within which to apply conjoint analysis including choice experiments, contingent ranking, paired comparisons, contingent rating and self-explication. Whatever format is selected, the choices that respondents make are statistically analysed using discrete choice techniques to determine the relative values for the different characteristics or attributes. If one of the characteristics is a monetary price, then it is possible to compute the respondent's willingness to pay for the other characteristics.

9.105 Because conjoint analysis focuses on trade-offs among scenarios with different characteristics, it is especially suited to policy decisions where a set of possible actions might result in different impacts on natural resources or environmental services. For example, improved water quality in a lake will improve the quality of several services provided by the lake, such as supplying drinking water, fishing, swimming and biodiversity. In addition, while contingent choice can be used to estimate monetary values, the results may also be used to simply rank options, without focusing on monetary welfare measures (Hanley and Mourato, 1999; Morrison and others, 1999).

9.106 The hypothetical choices in conjoint analysis can relate to both market and non-market goods and services. If it is applied to market prices, then the estimated values are compatible with SNA values. However, if the technique is applied to willingness-to-pay values, the same ambiguities apply as in the contingent valuation method.

4. Benefit transfer

9.107 Benefit transfer is not a separate pricing technique as such but a practice that is sometimes used to estimate economic values for ecosystem services by transferring information available from studies already completed in one location or context to another. This can be carried out as a unit value transfer or a function transfer.

9.108 In a unit value transfer, it is assumed that the well-being of the average individual at the study site is the same as that of the average individual at the policy site. This cannot be effected between countries with different income levels and standards of living without making income adjustments. Studies have found error rates of plus or minus 38 per cent on willingness to pay to avoid symptoms of respiratory illness across a number of European countries, compared with an error within a country of plus or minus 16 per cent arising from Monte Carlo studies.

9.109 Benefit transfer is more appealing than unit value transfer because more information is transferred in the former. It can be used in conjunction with travel cost and hedonic pricing (revealed preferences) as well as with contingent valuation or choice experiments (stated preferences). The willingness to pay is set up as a function of the characteristics of the environmental good or service and the characteristics of households. To apply this, the analyst needs to find a study in the literature with estimates for the coefficients and apply them to his own data values using the estimated equation.

9.110 In addition to the use of just one valuation study, work has also been done on combining data from several studies in meta-analysis. Environment Canada and the United States Environmental Protection Agency have set up the Environmental Valuation Reference Inventory (EVRI), a network and database of valuation studies categorized by various characteristics. EVRI includes the database, a module to capture new studies, a search engine and a screening module. As of March 2000, the database contained detailed descriptions of about 700 environmental valuation studies, primarily from North America. Its extension to include more valuation studies undertaken in Europe was under way at the time of the writing of this Handbook.

9.111 Comparative research in benefit transfers has only just begun. Preliminary results suggest that often the results transferred are within a range of plus or minus 50 per cent of the "true" value (that is, a value established by directly applying a valuation method to the new site). In principle, transferability achieves best results when:

(a) Data to be transferred are adequate;

(b) Populations are similar;

(c) The goods or services in question are similar;

(d) The sites are similar;

(e) The "markets" (that is, the context within which the choice is being made) are similar (for example, they are of similar sizes and have similar substitutes at hand).

9.112 The advantages of using benefit transfer methods may be measured primarily in terms of saving time and costs. Benefit transfer is often used in cases where it is too expensive or there is too little time available to conduct an original valuation study, but some measure of benefits is needed. However, benefit transfers can be only as accurate as the initial study. In addition, caution needs to be exercised in respect of the transferability of costs and preferences from one situation to another.

5. Assessment of different benefit/damage pricing techniques

9.113 ***Market prices*** are conceptually preferable but difficult to implement in practice because the subjects concerned are not only items that are currently not marketed but also those for which it may be difficult to envisage normal markets. In these cases, other pricing techniques must be used.

9.114 The ***travel cost*** and ***hedonic price*** methods are quite limited in terms both of the environmental services and assets they can cover and of the provision of national aggregates for those issues. The market valuation of economic losses is also limited in scope, since it focuses on marketed assets and well-defined goods and services.

9.115 A common feature of the ***stated preferences*** valuation techniques is their focus on limited, local and relatively small environmental questions. For the construction of environmentally adjusted national income figures, these estimates of the values of all the various environmental services need to be aggregated to a national level. This is a formidable problem, as recognized, for example, by Atkinson and others (1997).

9.116 Applying the ***contingent valuation*** method is generally a complicated, lengthy and expensive process. In order to collect useful data and provide meaningful results, the contingent valuation survey must be properly designed, pre-tested and implemented. Contingent valuation survey questions must focus on specific environmental services within a specific context that is clearly defined and understood by survey respondents. A contingent valuation survey to access the monetary value of the results of an environmental improvement cannot be based on the environmental improvement itself but on increases in specific environmental services that the improvement is expected to generate.

9.117 Equally significant have been efforts having the more pragmatic intention of arriving at values that are acceptable for policy makers. Particularly influential have been the recommendations of the NOAA Panel. The general conclusions drawn by the Panel have given some legitimacy to the application of the contingent valuation method in assessment of environmental benefits/damages (provided that the Panel's guidelines are followed). Although still controversial, the contingent valuation method has managed to gain increased acceptance among both academics and policy makers as an applicable methodology for estimating the monetary value of environmental changes.

9.118 Another United States study group (the Panel on Integrated Environmental and Economic Accounting, chaired by William Nordhaus) recognized in its report that "non-behavioural approaches such as contingent valuation have not been thoroughly calibrated and tested to ensure that they are reliable proxies for actual behaviour". The report went on to state that "although there are difficulties with non-behavioural approaches such as contingent valuation, work on the development of such novel valuation techniques will be important for developing a comprehensive set of production and asset accounts" (Nordhaus and Kokkelenberg, 1999). However, other expert panels, like the Advising Committee on Integrated Environmental and Economic Accounts at the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, are more reluctant to see contingent valuation used in the context of environmental and economic accounting on a national level.

D. Degradation crossing time and space

9.119 It has been noted, above that the agent producing degradation is often not the agent that suffers the damage and, similarly, the agent that incurs the costs of mitigating degradation is often not the agent that benefits. Further, the time period in which the degradation takes place may not be the same as the period in which the damage takes place, and the country where the degradation takes place may not be the one where the damage is experienced.

The time dimension

9.120 All of the preceding sections have assumed implicitly that degradation in a given period leads to damage in the same period and that damage in a given period arises from degradation in the same period. Clearly, this assumption is not always valid. Pollutants cumulate in environmental media and may cause damage long after they have been discharged from the economy. There is a limited discussion on the concept of "environmental debt" in chapter X.

Cross-boundary flows

9.121 The volume of residuals present, say, in a country's atmosphere does not necessarily coincide with the quantity of residuals generated by that country, since there may be movements of residuals in both directions across borders. The territory of a country does not necessarily coincide with discrete ecological areas. Some issues may pertain to a watershed or river basin that forms a country boundary. Taking account of these imports and exports of residuals is important politically as well as in terms of estimating the costs involved in avoiding damage. A discussion of the cross-border flows in physical terms appears in chapter III.

9.122 There is no exact way of estimating the value of the damage caused by the domestic country in another country because, in general, the necessary information (the local dose-response functions, for example) will not be available. Usually, allowance for such damage is made based on volume measures. If the quantity of residuals generated locally accounts for 80 per cent of the residuals present in the country, 20 per cent of the damage is assumed to be caused by imported residuals. It is not possible to distinguish damage caused by the same residual according to the country of origin: the damage suffered is related to the level and not the source of the pollutant. If, on the other hand, the residuals present in the country are only 80 per cent of those generated, clearly some have been exported. Evaluating the damage caused in a foreign country may be problematical. The exact costs will depend on the local conditions which may be very different from those of the residual-exporting country.

9.123 As part of the GARP project, estimates have been made of the damage transfer between EU countries for 1995. These are shown in Table 9.1. The first column shows the value of the damage from residuals as generated in each country in billions of European currency units (ECUs). The next column shows, in percentage terms, how much of the damage was inflicted on the economy where it was generated. Only in Germany, Greece, Italy and the United Kingdom was this more than half the total. For all the other countries, more than half the total was "exported". The third column shows the export proportions. For EU as a whole, the proportion retained and the proportion exported were each close to half the total. Smaller landlocked countries tend to export more than those with larger land areas and seacoasts. This is not a general rule, however. France, which satisfies both these conditions, exported two thirds of the damage generated owing to the fact that much of the heavy industry is concentrated in the east of the country, near borders with other countries, where the prevailing winds are westerly.

9.124 There is no symmetry between the export and import of damages except at the total level. The column for imports shows the imported damage as a proportion of what was generated domestically. For Austria, for example, just over twice as much was imported as was generated, making it one of the largest net importers of damage. The other net importers were Belgium, Denmark, Finland, Germany, the Netherlands and Sweden. The remaining eight countries were net exporters.

9.125 These figures concern flows only between the EU countries. Figures for flows to and from the rest of the world were not available but significant, especially for those countries to the east of the EU boundaries.

Table 9.1. Transfers of damage between European countries

	Billions of European currency units	Percentage of domestic generation			
	Generated	Retained	Exported	Imported	Received
Austria	1 204	28.4	71.6	204.3	232.6
Belgium	4 392	12.6	87.4	89.8	102.4
Denmark	1 207	17.5	82.5	173.1	190.6
Finland	242	48.7	51.3	116.5	165.2
France	23 152	33.5	66.5	59.0	92.4
Germany	34 375	64.1	35.9	54.9	119.0
Greece	2 026	77.1	22.9	21.6	98.7
Ireland	747	10.1	89.9	43.5	53.6
Italy	15 829	58.3	41.7	38.4	96.7
Luxembourg	287	0.6	99.4	34.3	34.8
Netherlands	4 880	19.8	80.2	123.6	143.5
Portugal	1 572	27.5	72.5	48.9	76.3
Spain	13 526	34.0	66.0	31.7	65.8
Sweden	536	31.7	68.3	360.2	391.9
United Kingdom	24 727	52.1	47.9	26.3	78.5
EU total	128 700	47.3	52.7	52.7	100.0

Source: Commission of the European Communities (1999).

E. Summary and conclusions

1. Methodological reservations

9.126 An objective often put forward by economists for environmental cost-benefit analysis is to compare the costs of obtaining further environmental improvement (or avoiding further damage) with the benefits obtained. The situation where the cost of reducing by one extra unit the environmental damage is equal to the value of the extra benefits obtained, represents an economically optimal level of goods and damages production. This optimization approach requires monetary estimates of the "marginal benefits" and "marginal costs" of the environmental protection or enhancement action.

9.127 Unfortunately, none of the methods for valuing unpriced environmental services and assets reviewed in previous sections is ideal for this purpose, and several drawbacks must be noted when these methods are used on a sectoral or national scale and under the consistency requirements of the national accounts. These drawbacks refer to issues such as coverage (some methods can be used to value only a very limited sub set of environmental services or assets), incompatibility with the valuation principles of national accounts in terms of the time they refer to or the values they generate, and the difficulties and costs of obtaining and interpreting the basic data (physical and monetary) needed for these valuation methods.

9.128 Quite apart from estimation difficulties, it is important to note that cost and benefit considerations usually arise separately and do not automatically balance. In particular, in order to link cost-of-supply figures to "environmental value" as such, it would be necessary to introduce the proposition that the (marginal) cost of supply is equal to the (marginal) environmental benefit. Since this is not automatically true (and, indeed, will usually not be true in any real situation), it is important to assess the extent to which and under what circumstances this proposition is likely to be approximately valid or can be considered a policy reference point.

2. Suitability of pricing techniques

9.129 The valuations of the environment obtainable through observation or inference of people's actual choices fall into four main categories:

(a) Real costs incurred due to legally binding avoidance, compensation or restoration obligations;

(b) Expenditure voluntarily undertaken to avoid or limit damage;

(c) People's "revealed" preferences for obtaining specified environmental services or amenities;

(d) People's "stated" or hypothetical preferences as elicited through contingent valuation (that is, willingness-to-pay or willingness-to-accept enquiries).

9.130 Monetary estimates of environmental benefits and damages can have a clear policy relevance but the "prices" are not necessarily comprehensive in the sense of taking into account all environmental benefits and damages.

9.131 The level of costs incurred, whether imposed by regulation or by choice, are seldom strictly determined by the level of any benefit that may result. The absence of a clear link can be due either to estimation difficulties because the full costs and benefits are not known when the estimates are made or, simply, to the fact that not all of these are taken into account.

9.132 Travel cost and hedonic pricing methods reveal preferences from the behaviour of consumers in markets. Figures obtainable through both these sorts of analyses put a monetary value on the specified individuals' or agents' preferences for environmental goods and against damages relative to other uses of their own time and money. These payments most often relate to tangible use values of the environment over which the user has some power of choice. They cannot be expected to cover the value that might be attached to the feature or amenity by others or in the future.

9.133 The same remarks apply, generally, to the stated willingness to pay (or the demand for compensation). Individuals may state a willingness to pay for an environmental amenity. A commercial firm may express such a willingness for access to a needed input or environmental service such as timber, volumes of water of a particular quality, or use of a river or sea as a receptacle for waste. The fact that the absence of any real market for the goods or damages in question makes it impossible to demonstrate that contingent valuation establishes "correct" prices, inevitably leaves the figures obtained open to controversy.

9.134 On the benefits side, it is generally agreed that there can be estimation difficulties. Some of these relate to "non-capture" of identifiable categories of benefits or damages in the valuation. Others, however, relate to difficulties in respect of the subject matter. While the national accounts studiously avoid placing values on externalities since the pricing techniques applied in national accounts are not well suited to their inclusion, the application of environmental cost-benefit valuation techniques involves the attempt to extend and transpose traditional economic valuation methodology into this area.

3. Data limitations

9.135 As the descriptions of the valuation methods show, the existence of physical data sets and accounts are a crucial precondition for valuation in various respects. Physical quantities such as stocks of environmental assets, volumes of flows of environmental services, volumes of residual flows, extent of environmental damage in physical terms etc., are necessary to determine the total values. In addition, for some methods, detailed interlinked physical accounts are necessary to enable valuation and to support the analytical applications of the environmental accounts. Cases in point are avoidance-cost calculations, and damage valuation using dose-response functions, where detailed data on the technologies used by different industries and households, on the residual flows generated by industries and households etc., are necessary.

9.136 Using the described valuation methods in the SEEA context imposes certain conditions. It is essential to avoid double counting and to be careful that the valuations are compatible when using different valuation methods simultaneously. When valuing on the benefit/damage side, it is often necessary to use several valuation methods to capture as many affected values as possible, since the available methods cover different aspects of the benefit/damage. On the cost side, avoidance and restoration costs can be overlapping.

9.137 In the case of pollution, the damage-side and the cost-side valuations are incompatible if a significant part of the pollutants deposited come from abroad, since the avoidance costs refer to domestic emissions. Further, if the damage valuation is limited to a few of the effects, as is often the case when applying market price methods, it should be underlined that the valuation is only a lower bound for the damage costs.

9.138 A popular view among environmental economists is that making estimates of the economic costs of avoiding particular categories of damage or natural resource depletion is a (relatively) straightforward undertaking but that obtaining monetary estimates for the benefits of such action is much more speculative. In fact, detailed empirical work on firm-level environmental expenditures and statistically based sectoral estimates of abatement cost curves suggests that cost-side information is very heterogeneous and often somewhat speculative, even for well-defined investment and technology choice situations. Consequently, even though more firmly based than damage estimates, robust “supply-side” valuation information is not as easy to come by as one might hope. An illustration of this can be found in the GREENSTAMP project (Brouwer an others, 1998).

Chapter X. Making environmental adjustments to the flow accounts

A. Overview

1. Introduction

10.1 Chapters III - IX described various aspects of environmental accounting as currently practised. They covered physical accounts and some aspects of monetary accounts either alone or in combination. All the techniques discussed therein are relatively new. There is some, but very little, history of these types of accounting going further back than a decade. When the SEEA 1993 was published, it was in a real sense a blueprint of what might be done rather than a discussion of what had been done.

10.2 Significant progress has been made in the last decade. Instead of environmental accounting being an occasional one-off exercise in a developing country, many of the techniques described in the earlier chapters have become embodied in statistical work programmes, particularly in the countries of the European Union (EU) thanks to the leadership and financial assistance provided by Eurostat. Even so, those countries involved in this process would be among the first to recognize that much remains to be done. Accounts for environmental protection expenditure may be established, but those for resource management are much less well developed. Hybrid supply and use tables for air emissions are now almost commonplace but similar accounts for water use and waste disposal are still in their early stages. Thus, while noting the enormous strides made in environmental accounting over the last 10 years, it is a legitimate question to ask what has not been done.

10.3 The largest question is, Can we calculate a measure of gross domestic product (GDP) that adequately accounts for demands placed on the environment? The simplest and most honest answer is that there is no consensus on how "green GDP" could be calculated and, in fact, still less consensus on whether it should be attempted at all. Instead of reviewing current best practice, the present chapter is more tentative and thus less consensual. It tries to be deliberately two-faced. On the one hand, it aims to look over the very edge of the present developments in environmental accounting and to describe what may be the potential ways forward to some measure of a "greener" GDP. On the other, it tries to spell out exactly what the risks are of pushing the techniques beyond their statistical and theoretical underpinnings. It is for each reader to make a considered choice, based on both sets of information, of his or her own view whether a measure of green GDP is desirable, practicable or feasible. This Handbook deliberately makes no value judgement on the issue. It aims simply to say this is how you might proceed and this is why you may decide not to do so. The fact that the whole of this Handbook is likely to be subject to significant revision in the short to medium term applies in particular to this chapter.

2. Objectives

10.4 The theme of this chapter is how the conventional national accounts could be adapted to show the interaction between the economy and the environment in monetary terms. Proponents of making environmental adjustments to national accounts aggregates usually cite three concerns reflecting their feeling that the SNA does not pay adequate attention to the use of the environment. First, when environmental assets, such as oil, are "used up", an adjustment should be made to show that the conventional measure of domestic product is overstated because no allowance has been made for the ***depletion*** to the stock of the asset. Second, measures to protect the environment, that is, ***defensive expenditures***, correct only some of the harm done by an activity measured elsewhere in the accounts, hence it is incorrect to count both the harm done and the correction. Third, despite the fact that some defensive expenditure does take place, there is additional harm done to the environment that is not remedied, hence the resulting ***degradation*** should also be treated as a decline in the environmental wealth of the nation and the manner in which it is taken into account should be similar to that applying to the decline in other stocks of wealth.

10.5 One section of this chapter is devoted to each of these topics. Within each section, there is discussion of the theoretical considerations behind the reasons for and against bringing the issue into the satellite account measure of macro-aggregates.

Depletion

10.6 Section B is concerned with measuring depletion. It starts from the discussion in chapter VII on how to estimate the value of the stock of a natural resource and considers how changes in the value of the stock might be considered to affect the value of national income. Depletion of cultivated livestock has always been accounted for in the calculation of GDP and, since the introduction of the 1993 SNA, so has depletion of cultivated plants. Economic accountants have long been aware that the SNA does not treat consumption of fixed capital and depletion of natural resources in a parallel manner. Section B discusses how non-cultivated biological resources, land and subsoil deposits might be handled in a similar way to that of their cultivated biological counterparts. It also discusses the possibility of treating those natural resources (oil and gas, for example) that are the subject of activities such as exploration that add value to the resources as fixed capital.

10.7 The theoretical and practical issues discussed in this chapter echo those described in chapter VII since the possibility of determining the impact of depletion on income depends crucially on being able to estimate the changes in value of the stock of an asset and the reasons for those changes.

10.8 Natural resources have owners and, besides considering the possible impact on national income, section B also discusses the impacts on income at a sectoral level. This may be of particular interest when the user of the resource is not the same unit as the owner, so that the benefit accrues to one sector and the cost falls on another.

Defensive expenditures

10.9 Defensive expenditure is the subject of section C. This term, which is widely used by commentators on environmental accounting but seldom by national accountants, can be applied to various types of expenditure including, for example, defence expenditure. The concern here is with expenditure undertaken to combat environmental degradation, although it is difficult to be entirely specific about what constitutes defensive expenditure. Environmental protection expenditure is one clear candidate in this regard. Other candidates include the administration necessary to establish and monitor fishing quotas or health expenditure related to atmospheric pollution.

10.10 In much of the discussion in section C, environmental protection expenditure will be used as the prototypic example of defensive expenditure. Environmental protection expenditure is already measured in the economic accounts. The means by which this is done are discussed in detail in chapter V. The problem is that some commentators perceive an asymmetry between current environmental protection undertaken by government which adds to the measure of economic activity and that undertaken by private industry which on the whole does not. The reasons for this asymmetry, and for rejecting the simplistic proposal to simply omit all environmental protection expenditure from GDP, are discussed.

10.11 As a better measure of total environmental protection activity can be obtained as explained in chapter V, by changing the SNA conventions on measuring ancillary activity, a similar adjustment of the conventions is proposed that would lead to the symmetric treatment of all environmental protection expenditure in the accounts.

Degradation

10.12 Both depletion and defensive expenditures are measured in the national accounts. It is the convention by which they do or do not affect the conventional aggregates the need to be discussed. In contrast, most degradation is not measured in the conventional accounts. A notable exception is degradation of land, but this is usually encompassed under the heading of depletion. Degradation of air and water is not measured directly, though some consequences may be captured indirectly, for example, health expenditures associated with atmospheric pollution. Section D discusses how the accounts can be used and extended to reveal a measure of domestic product and income that pays attention to the qualitative state of environmental media as well as to the quantitative stock of natural resources.

10.13 There are two main ways to approach the problem: the wealth approach explores how far the stock of assets is damaged by a fall in the quality of environmental media; and the income approach tries to quantify the income available for use when environmental standards are upheld. In the discussion of the alternative ways to place a valuation on degradation in chapter IX, it was made clear that there is no guarantee that cost-based and damage-based estimates of degradation will be equal; indeed, in general, they will not be equal. Therefore, incorporating adjustments based on these valuation methods will not give alternative measures of macroeconomic aggregates or, to be more precise, a measure of stocks and one of income that are perfectly coherent. This lack of coherence as well as an approach to restore the coherence is also discussed in section D.

10.14 Translating valuations of degradation into adjustments to macroeconomic aggregates takes us beyond the realm of ex post accounting into a much more hypothetical domain. The speculative nature of this sort of accounting means that this is the area that produces the greatest discomfort and strongest resistance in many accountants. It is not only the theoretical and practical problems of the techniques proposed that have to be considered, but also the institutional responsibility of the account compilers.

Completing the accounts

10.15 Chapter VII discussed the basis of valuing natural resources and how the value entered in an asset account or balance sheet was related to the resource rent that accrued in an accounting period, as well as how part of the resource rent could be identified with a decline in the value of the resource stock and part could be taken as the return to the resource. This chapter builds on that analysis to show how the flows of resource rent carry through the whole of the accounting system and how the accounts might be extended to permit variations in the conventional macroeconomic aggregates to be revealed.

10.16 No single alternative satellite account is recommended. In sections B - D, a set of options is presented on possible approaches to the topic under discussion. Together, they encompass a range of alternatives, some closer in nature to the conventional accounts and others less so.

10.17 Section E looks at the sets of options available and considers which may be combined and which are internally inconsistent. It recapitulates the theoretical and practical issues involved. There is also consideration of the practical possibilities, given the data needs and availability, and a consideration of the quality of any possible adjustment. It contains example accounts for key resources consistent with tables in earlier chapters. It reaffirms the point made in this chapter at the outset, namely, that there are no recommendations to be made on what should be done in this area; there is simply a set of options that might, at some point, be considered by some people.

10.18 In a book of their length, it is to be expected that some readers will ignore part or all of the earlier chapters and that some will not read the present chapter. Furthermore, it should be acknowledged that some of those who collaborated in the preparation of the Handbook would have preferred to omit this chapter. A number of reasons underlie this position. Some people still have serious reservations from a theoretical point of view about incorporating the presumed effects of environmental flows into the well-established economic accounts. Other reservations have a practical rather than a theoretical basis, namely, the fact that the data problems are still too formidable with respect to proceeding at this time. Some statistical offices are constrained by institutional responsibilities to restrict their attention to past and observed behaviour and it is often argued that, in these circumstances, while staff of a statistical office can and should collaborate with external researchers in exploring environmental accounting issues, it is not appropriate for the statistical office to undertake this work directly and alone. Directed against these misgivings are the arguments that the proposals included here are the logical culmination of the work described in the preceding chapters and that to omit the chapter would be to leave the work incomplete in an important respect. Readers interested in hypothetical accounting should be able to find here not only some guidance regarding the implications of the work described in previous chapters for proceeding towards adjusted aggregates but also warnings regarding the difficulties and uncertainties involved. This, and only this, is what the chapter aims to provide.

B. Depletion

10.19 Before addressing the question how to account for depletion, it would be useful to recapitulate the discussion on asset accounts and on the calculations associated with economic and resource rent presented in Chapter VII.

1. Asset accounts

10.20 Table 7.4 exhibits the format of the SNA asset account and Table 7.11 shows how the asset account interfaces with the flow accounts of the system. Opening stocks are subject to changes due to transactions (which are recorded in the capital and financial accounts) and to changes not due to transactions (which are recorded in the other changes in assets account) on the basis of which a figure for closing stocks is derived. Changes in produced assets appear in the flow accounts of the system unless they concern catastrophic losses, obsolescence, valuation changes or reclassification due to changes in ownership and structure.

10.21 Most of the items that appear in the SNA account for other changes in assets relate to the economic appearance and disappearance of non-produced assets. These assets are recorded in the flow accounts only when they are the subject of transactions, for example, their purchase or sale. Many of these non-produced assets are environmental assets, specifically natural resources and land.

10.22 Table 7.5 and the discussion centred around it show how the SNA asset account can be slightly reformulated as a SEEA account for environmental assets. The idea was introduced of additions to and deductions from stock levels which included the SNA items in the other changes in assets account relating to economic appearance and disappearance of environmental assets but allowed for physical appearance with no monetary valuation and excluded monetary disappearance when there was no corresponding physical disappearance. Other than these two main groupings of items, the same three items, namely, catastrophic losses, valuation changes and reclassification due to changes in ownership and structure, are left as other changes in assets as in the SNA account for produced assets.

10.23 At the heart of the discussion about integrating environmental issues within standard economic accounting lies the subject of incorporating additions to and deductions from the stock of natural resources within the flow accounts. The rationale for this lies in a shift in the primary focus of the economic accounts from a concentration on production itself to a consideration of how economic production affects measures of wealth, which include environmental assets, and measures of income, which are concerned with maintaining the levels of these assets as well as of produced assets.

2. Economic rent and resource rent

10.24 There is a general understanding that the use of natural resources could be measured in a way that is broadly consistent with the use of fixed capital. This assumption underlies the discussion in section VII.D on how stocks of mineral resources should be valued. Like fixed capital, the stock value can be estimated, at least theoretically, as the net present value of the future stream of benefits arising from the use of the resource. The benefits are equated with economic rent which is embodied in the gross operating surplus of an enterprise. This can be partitioned into two parts, one part relating to the economic rent derived from the use of produced assets (fixed capital) and the other part due to the use of non-produced assets (natural resources). The term "resource rent" refers to this second element, that part of the gross operating surplus of the enterprise using the resource that is not attributable to the fixed capital at the unit's disposal.

10.25 Further, as also explained in chapter VII, the economic rent arising from the use of a fixed asset can be partitioned into an element representing the decline in value of the asset, that is, the consumption of fixed capital, and a remaining element which is taken to be the income arising from the use of the asset and incorporated in the net operating surplus of the unit. Similarly, the resource rent can be partitioned into an element showing the decline in value of the natural resource and one showing the return to its use. The algebraic derivation of this partition is given in the following paragraph.

10.26 In chapter VII, the notation RR_t for the resource rent was introduced to represent a unit resource rent in period t (denoted by rr_t) times the level of extraction E_t. As before, r represents the discount rate, and n the life length of the asset. RV_{t-1}, the value of the asset at the end of period t-1 (that is, at the start of period t), can be written as

$$RV_{t-1} = \frac{1}{(1+r)} RR_t + \frac{1}{(1+r)^2} RR_{t+1} + \frac{1}{(1+r)^3} RR_{t+2} + ... + \frac{1}{(1+r)^n} RR_{t+n-1}$$

This formula assumes that the rent is paid at the end of the year, thus even the first year's rent needs to be discounted. Transforming the equation leads to

$$RV_{t-1} - \frac{RV_t}{(1+r)} = \frac{RR_t}{(1+r)}$$

By manipulation of this equation, the resource rent RR_t can also be written as

$$RR_t = (RV_{t-1} - RV_t) + rRV_{t-1}$$

The first of the terms in the last equation shows the difference in the value of the asset between the start and end of the period in question. The second term, equivalent to the income element in year t, represents the return to the capital asset in question.

10.27 At this point, a decision has to be made about the way natural resources are to be regarded. Box 10.1 describes three perspectives on how to identify the income element of the resource rent. One view is that the resources are so abundant that the whole of the resource rent can be regarded as income. As pointed out in chapter VII, this was the assumption in the 1968 SNA. This is equivalent to saying that the term RV_{t-1} - RV_t is zero, in other words, that there is no decline in the value of the stock of the resource.

10.28 Another view is that the value of the resource in the future would be the same to future generations as it is to present generations today. There is thus no applicable rate of discount (r=0) and the second term in the last equation becomes zero leaving the whole of the resource rent to be treated as the decline in the value of the stock of the natural resource. Another interpretation of this view is simply that revenues obtained from selling natural assets are not income from production and thus all should be excluded from NDP, even those coming from the sustainable use of a renewable asset. This is the view advanced, for example, by Vanoli (1995).

10.29 This last view is equivalent to saying that natural resources should not be regarded as factors of production in the same way that fixed capital and labour are, because they were not produced. Although land is a natural resource, it has traditionally been regarded as a factor of production and income arising from its use as part of income from production. Most commentators would extend this treatment to all natural resources and would thus choose to partition the resource rent between an element that is regarded as income and one that is regarded as the using up of the asset. The solution, though, has to be generalizable to the case when the income element is either zero per cent or 100 per cent of the resource rent.

10.30 There is an extensive economic literature on this topic. One way of partitioning the resource rent into a perpetual income stream and a depletion element was put forward by El Serafy (1989) as the "user cost approach". The resource rent (*RR*) in any period is split into an income element (*X*) and a depletion element (*RR-X*). The assumption is that the resource would provide an equal economic rent for each of *n* years, so that its value is the net present value over *n* years of *RR*. The income element has to be such that the net present value of *X* over an infinite period has to be the same as the net present value of the resource. The net present value of the resource is

$$NPV(RR) = RR\frac{1-\frac{1}{(1+r)^n}}{1-\frac{1}{1+r}} = RR\frac{(1+r)}{r}\left\{1-\frac{1}{(1+r)^n}\right\}$$

The net present value of the income stream is simpler since it is the infinite sum

$$NPV(X) = X\frac{1}{1-\frac{1}{1+r}} = X\frac{(1+r)}{r}$$

Setting these equal, the proportion of each year's resource rent that should be treated as income can be derived. It is

$$\frac{X}{RR} = 1-\frac{1}{(1+r)^n}$$

Other methods include those of Hotelling (1931) and Hartwick (1990). Whichever method of splitting income and extraction is used, the longer is the life length and the higher is the interest rate, the greater will be the share of income. If a zero rate of interest is used as a social discount rate, which assumes that the benefit of resources to future generations has the same value as the benefit today, then there is never an income component to the economic rent: it is all regarded as extraction.

Box 10.1. Options for identifying the income element of resource rent

Option A1. All resource rent represents income. In this case $RR_t = rRV_t$ because RV_t is equal to RV_{t-1}.

Option A2. No resource rent represents income; it is all a decline in the value of the resource. Thus $RR_t = (RV_{t-1} - RV_t)$ because the rate of return, r, is taken to be zero.

Option A3. Part of the resource rent represents a decline in the value of the asset and part is income. In this case, $RR_t = (RV_{t-1} - RV_t) + rRV_{t-1}$.

Consumption of fixed capital and depletion

10.31 The first term on the right-hand side of the equation for resource rent given in paragraph 10.26, namely, $RV_{t-1} - RV_t$, represents the value of the decline in the asset under consideration. For produced assets, it corresponds to consumption of fixed capital. For non-produced assets, or a natural resource in this case, it may be called instead the depletion of natural assets.

10.32 The term “depletion” is commonly used with different meanings. It is sometimes used to denote the total volume of extractions of natural resources times the unit resource rent; and sometimes used to signify the effect of extractions on the value of the stock of the resource, once the return to natural resources has been taken into account. In this Handbook, the term “extractions” (and sometimes the term “harvest”, and sometimes both terms) is used in the first sense and is synonymous with resource rent. Depletion is used, as in the SNA, in the second sense to mean the change in value of the stock of the resource.

3. Accounting for changes in the stock levels of environmental assets

10.33 Any use of an environmental asset raises the possibility of some deductions from stock levels, hence this item will be discussed before the recording of additions to stock levels. It is also useful to look into the difference between recording gross deductions and recording deductions net of additions. First, however, we will review the derivation of rent in the accounts.

Deductions from the stock of environmental assets

10.34 The generation of income account in the SNA is very simple. Under resources, it shows gross value added as generated in the production account and under uses, compensation of employees and payment of taxes on production less any subsidies received, leaving gross operating surplus as the first balancing item. From this, consumption of fixed capital is deducted to leave net operating surplus, as shown in Box 10.2.

10.35 For simplicity’s sake, taxes less subsidies on production are assumed to be zero in the present section and are not included in each representation of the derivation of various measures of operating surplus. Compensation of employees is included not only because it is always a large item but also as a reminder that in an industry with self-employed producers, a deduction for compensation of labour must be made to convert from “mixed income” to a measure equivalent to “gross operating surplus”.

Box 10.2. SNA generation of income account

Generation of income account
Gross value added
less compensation of employees
equals gross operating surplus
less consumption of fixed capital
equals net operating surplus

10.36 It is demonstrated in chapter VII that we can express gross operating surplus as the sum of two items, the economic rent on fixed capital and resource rent. If we deduct the economic rent on fixed capital (the value of the capital services they render) from gross operating surplus, we derive resource rent explicitly. If we then add back the returns to fixed capital, we again derive net operating surplus as measured in the SNA because the returns to fixed capital are equal arithmetically to the economic rent less consumption of fixed capital. Thus an extended form of the generation of income account can be developed as follows.

Gross value added

less compensation of employees

equals gross operating surplus

***less* value of capital services rendered by fixed capital**

***plus* returns to fixed capital**

equals net operating surplus

10.37 This account contains nothing that is not implicit in the SNA account: it simply partitions gross operating surplus into conceptual components. There are those who are not quite comfortable with the techniques involved for they to find them too far removed from direct observation. Yet, they are the same sort of techniques used to calculate consumption of fixed capital itself. This extended account provides information needed for productivity studies and a more comprehensive identification of the returns to natural resources. It also gives information on the value of total abstractions of natural resources.

10.38 Just as the consumption of fixed capital can be expressed as the services of fixed capital less the returns to fixed capital, so the impact of depleting assets can be expressed as the extraction of natural assets less the return on natural assets. If the impact of depletion (the value of the extractions less the return to natural resources) is deducted from the net operating surplus that has been derived, another balancing item can then be derived which may be called depletion-adjusted operating surplus.

Gross value added

less compensation of employees

equals gross operating surplus

less value of capital services rendered by fixed capital

plus returns to fixed capital

equals net operating surplus

***less* extraction of natural resources**

***plus* returns to natural resources**

***equals* operating surplus adjusted for the depletion of natural resources**

10.39 Because we are using depletion in the sense of a net change in the stock of an asset, the term "depletion-adjusted" extends the concept of net (of consumption of fixed capital) as applied to balancing items to mean "less the effect of usage of both fixed capital and natural resources".

10.40 The version of the account given here is the most general one, where it is assumed that the resource rent is partitioned into a depletion and an income element. If option A1 from Box 10.1 is used, there will be no depletion and therefore there will be no difference between net operating surplus and depletion-adjusted operating surplus. If option A2 from the same box is used, then there will be no returns to the natural resource, and depletion-adjusted operating surplus will be equal to the value of net operating surplus less the whole value of the resource rent arising from extraction.

10.41 In principle, such an account could be compiled for an enterprise, an industry (possibly at a disaggregated level such as oil extraction rather than all subsoil assets extraction) or for the economy as a whole. Before considering this sort of disaggregation, though, it is necessary to consider what adjustments, if any, should be made for additions to the stock of natural assets.

Increases in the stock of cultivated biological assets

10.42 Biological assets, being renewable, are somewhat trickier to account for than strictly non-renewable assets. Let us first consider produced or cultivated biological assets such as a herd of dairy cattle. The analysis developed so far holds for each individual animal existing at the beginning of the year. By the end of the year, the dairy cow is a year older and the potential future milk yields will be lower than at the beginning. However, for the herd as a whole, it is likely that some of the cows will have had calves that will be retained for milk production in future. Equally some of the cows alive at the beginning of the period may have died or been sent to slaughter. The herd of cows at the end of the period, therefore, is not necessarily the same as the herd at the beginning but one year older. While our analysis of the value of each individual cow fits the model we have developed, we cannot apply it to the herd in a collective sense without making allowance for the regeneration that takes place in a year.

10.43 The SNA makes it clear that the correct way to measure this regeneration is to measure the decline in the value of the cows extant at the start of the year and to treat this as consumption of fixed capital while at the same time measuring the addition of new stock as new fixed capital formation, very possibly produced on own account. In many cases, though, in as much as this advice could be followed only under ideal conditions, consumption of fixed capital will be calculated on the basis of the net change in the herd. (This may be particularly the case in developing countries where the only information regularly available is that on the total stock of animals at given points in time.) If there is no change in the size of the herd, and if the age composition of the herd does not change from one year to the next, there will be no change in its value. In such circumstances, in practice there may be neither gross fixed capital formation nor the exactly offsetting consumption of fixed capital recorded. When the composition of the herd does change, only a net figure may be recorded. Unless special adjustments have to be made for extraordinary events such as drought or devastating disease, the net figure will appear as net fixed capital formation if positive and consumption of fixed capital if negative. Although recording only net changes in capital formation gives net measures of income that are correct, conceptually, some income and some consumption of fixed capital is missing from the accounts.

Additions to the stock of non-cultivated biological resources

10.44 Non-cultivated biological resources, of course, also benefit from regeneration. As noted before, it is the assumption that there is no net reduction in the stock of natural resources that leads to the conclusion that there is no need to make an allowance for its depletion. This assumption is clearly unjustified in a number of cases, for example, those concerning tropical rainforests and wild fish stocks of many species.

10.45 The first adjustment that is helpful with respect to the elaboration of the generation of income account entails separating extraction of natural resources into two elements, one relating to biological (regenerating) resources and the other to non-renewable resources. For the moment, we will consider non-produced biological resources only and return later to non-renewable resources.

10.46 In the SNA, and the SEEA, gross operating surplus includes the resource rent from extractions or harvest of non-produced biological resources. The SEEA desires to identify this explicitly, and also to establish the impact on the stock levels of these resources. This may be carried out in two stages: calculating the impact on stock levels of the extractions and then allowing for the additions to the stock levels arising from natural growth. Alternatively, a single net effect on the level of the stock can be calculated that combines the effects of extractions and natural growth.

10.47 The previous version of the generation of income account can thus be amended as follows to accommodate these extensions:

Gross value added

less compensation of employees

equals gross operating surplus

less value of capital services rendered by fixed capital

plus returns to fixed capital

equals net operating surplus

less **gross** extraction of non-produced biological resources

plus returns to non-produced biological resources

***plus* natural growth of non-produced biological resources**

equals operating surplus adjusted for the depletion of non-produced biological resources

10.48 The relationship between depletion-adjusted operating surplus and net operating surplus depends on the relationship between the physical measures of harvest and natural growth. If they are exactly equal, there is no net depletion and so depletion-adjusted operating surplus is identical to net operating surplus. When the harvest is greater than natural growth, the depletion-adjusted operating surplus will be less than net operating surplus. The wider the gap between the two, the less sustainable the harvest. But what is recorded if natural growth exceeds the harvest?

10.49 In the case of a product for which there is no restriction on regulatory harvesting, it should be assumed that it is harvested up to the point where demand for the item is satisfied and that for any quantity in excess of this amount the marginal economic rent has fallen to zero. If the harvest exceeds this level, the price of the product will fall so that the harvester will not even cover his costs. Since the value at which non-cultivated assets enter the balance sheet is the economic rent, there is no extra value to be added even when there is a physical addition to the stock of the item over the year.

10.50 Suppose, on the contrary, that there are restrictions imposed on the harvesting of the product, for example, the existence of fishing quotas to prevent the ultimate extinction of species. The increase in physical stock levels would have a monetary value since the harvest had been truncated before the marginal economic rent sank to zero. On the other hand, unsatisfied demand may have increased the economic rent of those fish harvested by increasing the price for the landed fish. In this case, the outcome will depend on the market conditions.

10.51 What this does reinforce again, though, is the need to have both quantity and value information available in order to fully assess what is happening to the stock of an asset. The analysis directly above assumes that the composition of the stock in terms of species and age composition is unchanged over repeated periods of harvest and natural growth. If the stock in question is not homogeneous, then it is necessary to look at the harvest and natural growth by species and cohort separately.

Additions to the stock of other natural resources

10.52 Before considering the case of mineral and energy resources, it could be useful to review briefly the treatment of major repairs and improvements to produced assets in the SNA. A major repair to an asset such as an aeroplane is defined as one that increases its efficiency or prolongs its life. It is treated as gross fixed capital formation. This adds to the current value of the asset and slows, or at least prolongs, the decline in the future. Thus, there is an immediate impact not only on the value of the asset but also on the capital services it renders, the return to it and the value of consumption of fixed capital to be associated with it.

Land improvement

10.53 A particular case of interest is that of land improvements, which are described in the SNA as follows.

> "The total stock of land is not fixed. For example, it may be marginally increased or decreased by reclaiming land from the sea or by erosion by the sea. Its quality may also be improved by clearing forests or rocks and by building dykes, irrigation channels, windbreaks etc. Similarly, its quality may be damaged by inappropriate agricultural use, pollution, natural disasters etc. Activities that lead to major improvements in the quantity, quality or productivity of land or prevent its deterioration are treated as gross fixed capital formation and shown separately in the classification. These activities represent productive activity of institutional units that add to the value of land" (para. 10.122).

10.54 The appearance of new land is recorded as gross capital formation and not as economic appearance because it is the result of productive activity. In the balance sheet, though, the value of the produced part of land is aggregated with the much larger value of non-produced land into a single aggregate which is classified as a non-produced asset At the same time, however, the value of the land improvement is subject to consumption of fixed capital in the same way as other fixed capital formation, that is, the consumption of fixed capital is the change in value of the enhancement to the land. Where it is a question of structures such as dykes, the life length and decline in value may be obvious. For other improvements affecting the soil fertility directly, it may be that there is little if any deterioration.

Mineral and energy resources

10.55 Occasionally, there is complete and exhaustive knowledge about the extent of the mineral or energy deposit even before extraction starts. However, because by their nature most such deposits occur below ground level, this is seldom the case. Initial estimates of the extent of the deposit must be made and verified before it becomes economic to start extraction. Once extraction has started, it is common for the estimates to be revised, often - but not always - upward. The question to be addressed now is how to record the initial discoveries and subsequent revisions.

10.56 There is extensive discussion of the process of delineating mineral exploration from the valuation of the subsoil deposit itself and of the valuation options in section VIII.B. For convenience, the options given in Box 8.1 are reproduced here as Box 10.3. They are now qualified by the letter B to distinguish them from other sets of options in this chapter.

10.57 Options B1 and B2 are consistent with the SNA which states that the value of mineral exploration should be recorded as gross fixed capital formation in the form of an intangible produced asset while the valuation of the deposit is recorded as a tangible non-produced asset.

10.58 Unless separate valuations of each is available (option B1), the process of valuing the deposit using net present value techniques means that the higher the costs of exploration, the lower the value of the non-produced asset and vice versa (option B2).

10.59 An alternative, option B3, records a single asset incorporating the value of the exploration activity as well as that of the deposit itself. The combined asset, described as a developed natural resource, is recorded as a tangible produced asset. This allows additions to these sorts of natural resources to be treated in the same way as capital formation. This process of combining produced and non-produced assets into a single entry in the balance sheet is similar to that adopted for land; but in this case, since it is assumed that the produced element predominates, the single combined asset is treated as produced whereas land remains non-produced.

Box 10.3. Options for recording mineral exploration and mineral deposits

Option B1 is to record values for both the mineral exploration and the mineral deposit which come from independent sources, neither depending on a calculation of the resource rent of the deposit. There is no guarantee in this case that the sum of the assets will exactly match the net present value of the stream of resource rents: the total may be either greater or smaller than this depending on the assumption underlying the valuation of the deposit.

Option B2 is to record the value of mineral exploration based on either market prices or costs (depending on whether it is carried out by a contractor or on own account) and to base the value of the mineral deposit on the net present value of the resource rent calculated to exclude the value of mineral exploration.

Option B3 leads to values identical to those under option B2 but treats the sum of the two values as attributed to a “developed natural asset” which would be recorded as a tangible produced asset. By contrast, in the SNA, mineral exploration is classified as an intangible produced asset and the mineral resource as a tangible non-produced asset. There is no impact on of this change the asset account or on the balance sheet (except for headings used) but changes are implied for the flow accounts, as explored below.

10.60 Chapter VII contained an analysis of the effect of a number of factors - discoveries and reappraisals, extractions, the change in the extraction rate and the change in the resource rent - on the stock of mineral and energy resources. Changes due to price changes are treated in both the SNA and the SEEA as revaluation and are recorded in the other changes in assets account. Changes in the unit resource rent enter into this category. Changes in the extraction rate affect the level of the stock: the faster the extraction, the higher the value of the stock because the value of extraction in future years is discounted less. On the other hand, the decline in the value of the stock will be greater in each year of the shorter life length.

10.61 The impact on the accounting entries of a decision to extract faster or more slowly than in the past is determined by the actual level of extraction in the period in question. The higher the level of extraction, the higher the resource rent; the faster the extraction, the higher the depletion element. The other factor influencing the calculation of any change in the value of the stock comprises discoveries and reappraisals.

Combining additions and deductions to stock levels

10.62 The options for recording the effect of additions to and deductions from the stock levels of non-produced biological assets separately or on a net basis were discussed above. For mineral and energy resources, the position is somewhat more complex because of the option to merge the recording of mineral exploration and mineral deposits into a single "developed natural asset". Three options are given in Box 10.4 (C1 to C3) for showing how changes in non-produced biological assets and mineral deposits can be recorded in combination in the generation of income account.

10.63 Option C1 records harvest of non-produced biological resources and extraction of mineral deposits as deductions from net operating surplus.

10.64 Option C2 offsets some or all of the effect of extraction on the value of the stock level by the value of the additions to stock due to natural growth of non-produced biological resources and the discoveries and appraisals of mineral deposits coming from the activities of mineral exploration. Natural growth is included in this measure of operating surplus on the grounds that, although it is outside the production boundary of the SNA, it is a natural process that an economic agent can reasonably rely on to support rational economic behaviour. Natural growth is likely to exceed harvest only when active steps are being taken to rebuild stocks of a resource previously threatened and overexploited. Discoveries and reappraisals are included because they are the direct result of economic production. They can exceed extractions in any year but are unlikely to do so consistently for a very long period, if only because once a certain level of stocks has been confirmed, exploration is likely to be suspended. The value given to discoveries of mineral deposits will depend on the options chosen to value mineral exploration and, in general, the larger the element of operating surplus attributed to this production activity, the lower the resource rent for the deposit discovered. Note that under option C2 there is no economic rent and so no addition to gross operating surplus arising from the additions to stock from natural growth or mineral discoveries. They simply reduce the amount by which economic rent has to be offset by an allowance for the consumption of natural capital.

10.65 Mentioned above was the fact that, in practice, information on the stock of biological resources may sometimes be available only on a net basis with harvest and natural growth not available separately. This may sometimes be true also for subsoil deposits. In such circumstances, only a form of net recording of the effect on the value of the stock levels of extractions less discoveries will be possible. This is treated as a variation of option C2.

Box 10.4. Options for recording the additions to and deductions from the stock of environmental assets

Option C1 records the consequences of extraction of natural resources in the extended generation of income account leading to a depletion-adjusted operating surplus, but the corresponding increases in resources are shown in the other changes in assets account.

Option C2 records both the consequences of extraction and additions to natural resources in the extended generation of income account. Additions cover both the natural growth of biological resources and discoveries and reappraisals of subsoil deposits.

Option C3 is one where there are no entries for extraction of and addition to natural resources in the extended generation of income account of those assets that have been reclassified as developed natural assets and are therefore recorded in the same way as produced assets.

10.66 It is assumed here that it is logical either to include additions to the stocks of all natural assets or to exclude them all. Obviously, though, further variations are possible such as including natural growth but excluding mineral discoveries.

10.67 Option C3 concerns the case where option B3 is chosen for the recording of mineral exploration and the mineral deposits as a combined developed natural asset. This is then recorded as a produced asset and the consequences are included in net operating surplus. The adjustments to be recorded leading to a depletion-adjusted operating surplus are only those related to environmental assets that are not treated as developed natural assets.

4. A set of depletion-adjusted accounts

10.68 We are now in a position to see how the whole set of SNA accounts could be adjusted to allow for depletion of natural assets. This means looking at both the flow accounts and the accumulation accounts.

The sequence of accounts

10.69 Because of the ease of identifying the link between operating surplus and the use of capital, the illustrations provided by the present section are presented in terms of adjustments that could be made starting with the generation of income account where operating surplus is recorded. In principle, though, since the depletion-adjustment parallels that for consumption of fixed capital, a figure for depletion-adjusted value added could be shown in the production account consistent with the entries shown below for the generation of income account.

An extended generation of income account

10.70 Reflecting the discussions on the extractions of natural resources and the different ways in which additions to the stock of biological resources and subsoil deposits could be made, as summarized in Box 10.4, a single extended generation of income account for non-produced biological resources only that is in line with the versions presented earlier in this publication, is shown in Box 10.5.

Box 10.5. An extended generation of income account

Extended generation of income account
Gross value added
less compensation of employees
equals gross operating surplus
less value of capital services rendered by fixed capital
plus returns to fixed capital
equals net operating surplus
less extraction of non-produced biological assets
plus natural growth of non-produced biological assets
plus returns to non-produced biological assets
less extraction of subsoil resources
***plus* enhancement to the value of subsoil resources**
plus returns to subsoil resources
equals depletion-adjusted operating surplus

10.71 The same qualifications apply to this extended version as to the earlier version given above where additions to the stocks were not considered. They are made with reference to the most general case, where it is assumed that the resource rent is partitioned into a depletion and an income element. If option A1 from Box 10.1 is used, there will therefore be no depletion and there will therefore be no difference between net operating surplus and depletion-adjusted operating surplus. This is the SNA option, according to which all the additions and deductions shown in Box 10.5 following net operating surplus appear in the other changes in assets account. If option A2 from Box 10.1 is used, then there will be no returns to the natural resource and depletion-adjusted operating surplus will be equal to the value of net operating surplus less the whole value of extractions.

Other current accounts

10.72 The adjustments made to the balancing item of operating surplus carry through to the following balancing items of the successive accounts up to and including the use of income account, where the resulting balancing item, carried forward to the capital account, becomes a depletion-adjusted measure of saving.

An extended capital account

10.73 The adjustments included to bring net saving to a depletion-adjusted basis all concern the measurement of capital and thus corresponding adjustments are needed in the capital account to show how depletion-adjusted saving is affected by transactions and other flows to reach net lending or net borrowing. Just as consumption of fixed capital appears as a use of funds in the current accounts and a negative use of funds in the capital account, so do the other adjustments have to be similarly recorded. An example of the resulting extended capital account is shown in Box 10.6. Obviously, the entries in this account must match those in the generation of income account and so the options selected in respect of that account will carry through to the capital account also.

10.74 Note that a depletion-adjusted measure of capital formation is available from this account by aggregating the adjustment items with the entries for capital formation. This is then the measure of the impact of the total stock of produced and non-produced non-financial assets caused by economic activity in the period in question.

10.75 The figure reached for net lending or borrowing is identical with that in the standard SNA tables. Nor is there any change in the entries in the financial account up to the present.

Box 10.6. An extended capital account

Extended capital account
1. Depletion-adjusted saving[a]
2. *less* gross fixed capital formation other than land improvement[b]
3. *less* land improvement[b]
4. *less* changes in inventories[b]
5. *less* (acquisitions less disposals) of valuables[b]
6. *less* (acquisition less disposals) of non-produced non-financial assets[b]
7. *plus* the value of capital services rendered by fixed capital[c]
8. *less* returns to other fixed capital[c]
9. *plus* extraction of non-produced biological resources[d]
10. *less* natural growth of non-produced biological assets[d]
11. *less* returns to non-produced biological resources[d]
12. *plus* extraction of natural resources[d]
13. *less* enhancement to the value of subsoil resources[d]
14. *less* returns to natural resources[d]
15. *equals* depletion-adjusted capital formation[e]
16. *plus* capital transfers receivable[b]
17. *less* capital transfers payable[b]
18. *equals* net lending(+)/net borrowing(-)[b]

[a] Bearing the same relation to net saving as depletion-adjusted operating surplus does to net operating surplus.

[b] Standard SNA entry.

[c] Together with returns to other fixed capital equals consumption of fixed capital as shown in development of extended generation of income account. Since gross fixed capital formation is a deduction from saving, these items have their signs reversed to produce net fixed capital formation.

[d] Adjustment item from extended generation of income account. As with the previous items, the signs are reversed in this account in order to add to depletion-adjusted saving.

[e] Algebraic sum of items 1 - 14.

Accumulation accounts

10.76 Returning to a consideration of the asset account given in Table 7.4, we can see that all the entries concerned with additions to and deductions from the stock of environmental assets can be incorporated into the capital account by choosing the appropriate options from the various sets presented. The only entries left for inclusion in the other changes in assets account then relate to catastrophic losses, price revaluation and changes in classifications and structure.

Illustrations of options A, B and C

10.77 Table 10.1 presents illustrative data for the options described above for the recording of adjustments to operating surplus in the case of oil and gas extraction. The data basically show how entries in the other changes in assets account may be moved and included in the extended generation of account to change the balancing items representing income in the flow accounts. Since these changes do not affect net lending or borrowing, the same entries appear with the opposite sign in the capital account representing a reduction in wealth.

Table 10.1. Illustrations of options for recording adjustments to operating surplus

Billions of currency units

Options	A1 = SNA	A2	A3		
			B1		B2
			C1	C2	C3
Extended generation of income account					
Gross operating surplus	104.1	104.1	104.1	104.1	104.1
Consumption of fixed capital	24.9	24.9	24.9	24.9	24.9
Depletion of developed natural assets					12.8
Net operating surplus	79.2	79.2	79.2	79.2	66.4
Extraction (resource rent)		-58.3	-58.3	-58.3	
Return to natural resources			28.9	28.9	
Discoveries				16.6	
Depletion-adjusted net operating surplus	79.2	20.9	49.8	66.4	66.4
Capital account					
Extraction (resource rent)		58.3	58.3	58.3	
Return to natural resources			-28.9	-28.9	
Discoveries				-16.6	
Other changes in assets account					
Depletion	-29.4				
Discoveries	16.6	16.6	16.6		
Revaluation	22.9	51.8	22.9	22.9	22.9

Source: SEEAland data set.

10.78 Under option A1, which is the SNA option, the whole of the resource rent is treated as income. There are no adjustments in the generation of income account or capital account and there are three entries in the other changes in assets account - one for depletion, one for discoveries and one for revaluation.

10.79 Under option A2, none of the resource rent is treated as income: it is all taken to be depletion so net operating surplus is reduced by this amount. In the entries in the other changes in assets account, the amount for revaluation increases by the amount of the return on natural resources, leaving the same net effect on reserves as under option A1.

10.80 Option A3 allows for some but not all of the resource rent to be treated as income and provides the underlying assumption for the next three cases.

10.81 Columns three and four show the changes in the extended generation of income account when the resource is still treated as a non-produced asset but both extraction and discoveries are recorded in the year. Under option C1, resource rent and the return to natural assets are shown as the only two elements of depletion. Under option C2, discoveries are shown as the third component of the depletion adjustment. As items are included in the extended generation of income account, they are also included in the capital account and removed from the other changes in assets accounts.

10.82 The last column refers to the options where mineral exploration and the deposits are recorded jointly as a developed natural asset. Here the depletion adjustment as calculated under option C2 (12.8) is shown together with the consumption of fixed capital for (other) produced assets. There is thus no difference between net operating surplus and an adjusted version thereof, though depletion-adjusted net operating surplus has the same value as the depletion-adjusted operating surplus under option C2.

Attributing accounting entries to sectors

10.83 While these tables may be satisfactory at the level of the total economy, it is also necessary to investigate how the extra entries suggested would affect the accounts of various sectors. In particular, this means identifying what should be recorded when the owner of the asset and its exploiter are different: In whose balance sheets are the assets recorded and how are the payments from the user to the owner recorded?

Is the owner also the user?

10.84 When it is the owner who is also the extractor of the natural resource, the accounts as described above can be implemented for that unit exactly as for the economy as a whole. However, there are many cases where the owner is not the unit undertaking the extraction activity. Often government is regarded as the owner on behalf of the nation as a whole. Even in cases where the extraction is undertaken by a wholly public corporation, this will be shown within the non-financial corporate sector of the national accounts and thus separately it from the accounts of government as legislator and administrator.

Owner and user different

10.85 Here also we must have recourse to a number of options that can be chosen in a number of combinations. One set of options concerns the balance sheet in which the asset is to be recorded. This issue is discussed in section B of chapter VIII and the options given in Box 8.2 are repeated here for convenience, prefixed by the letter D. The second set of options relates to where the flows are recorded under each of the options in Box 10.7 for recording the ownership of the stock. This subject is discussed below.

Box 10.7. Options for recording the ownership of mineral-related assets

Option D1 shows mineral exploration in the balance sheet of the extractor and the value of the deposit in the balance sheet of the legal owner. If the agreement between the owner and the extractor allows for the extractor to retain some of the resource rent coming from the asset, the ownership of the asset should be partitioned consistently.

Option D2 shows both the mineral exploration and deposit as being under the de facto ownership of the extractor. In addition, the extractor has a financial liability towards the owner corresponding to his share of the resource rent. This amount is also shown as a financial claim in the balance sheet of the owner.

Assets recorded in the legal owner's balance sheet

10.86 This is the default case and the one assumed to obtain by the SNA. Payments from the user to the owner are recorded as property income. Property income is defined in the SNA as "the income receivable by the owner of a financial asset or a tangible non-produced asset in return for providing funds to, or putting the tangible non-produced asset at the disposal of, another institutional unit" (para. 7.88).

10.87 Property income is subdivided into a number of components all of which except one relate to financial assets. The exception is rent which is further subdivided into rent on land and rent on subsoil assets. Although only these two components are mentioned explicitly, it seems clear that, in principle, payments for the use of natural forests for logging or wild fish stocks for fishing would also be covered under the heading of rent.

10.88 Rent is recorded in the distribution of primary income account and represents a charge on the operating surplus of the institution paying the rent. As suggested by the name of the account where it appears, it is not a form of income-generation but of redistribution from the unit that has generated the income by the use of the asset, back to the owner of the asset.

10.89 As long as the asset suffers no depletion in the course of its use, this recording of the payment from the user to the owner is satisfactory for both the SNA and the SEEA. However, if the asset has suffered some measure of depletion, this may not be adequate. (Given the special characteristics of land, it is easiest to treat degradation of land as a special form of depletion.)

10.90 The problem is that, while it is the user who benefits from the capital services that the natural resource yields and while it is his activity that causes the degradation, it is the owner who suffers the decline in wealth caused by the depletion. One way to show this would be to partition the payment from the user to the owner into two parts, one corresponding to the return on the asset and one to the decline in the value of the asset. The first could be recorded as rent and the second as a form of capital transfer from the user to the owner as recompense for the decline in the asset's value.

10.91 A summary of the options for recording depletion when the assets are recorded in the balance sheet of the legal owner is given in Box 10.8.

10.92 These three options, all of which assume that option D1 regarding the ownership of assets is followed and that the asset is recorded in the balance sheet of the legal owner, are illustrated in Table 10.2. The consistency with the earlier options, or the lack of it, can be seen by comparing the entries remaining in the other changes in assets account.

10.93 Option E1 is strictly consistent with the SNA. Option E2 gives aggregate balancing items that are consistent with the SNA but the sectoral allocation differs from option E1, since part of the transfer of resource rent is recorded in the capital account.

10.94 Options E3 and E4 are the analogues of options C1 and C2. Options E3 and C1 both make a deduction for extraction from balancing items; options E4 and C2 include an adjustment for discoveries as well.

Box 10.8. Options for recording depletion: asset recorded in the legal owner's balance sheet

Option E1 is consistent with the SNA. This records the value of the depletion in the other changes in assets account.

Option E2 partitions the actual payment into two elements. The part that corresponds to the decline in value of the asset is recorded as a capital transfer from the user to the owner as recompense for the decline in the asset's value; the rest is recorded as property income (rent) payable from the user to the owner in the distribution of primary income account.

Option E3 maintains the recording of the actual payment from the user to the owner as property income in the distribution of primary income account but treats this as rent gross of depletion. An element for the consumption of natural capital is shown in this account for the owner also in order to reduce the rent to a value net of depletion.

Option E4 is similar to option E3 but assumes that the consumption of natural capital allows for the discoveries made during the year as well as the extraction.

Table 10.2. Illustration of options for the payments of rent

Billions of currency units

Option	E1		E2		E3		E4	
	Extractor	Owner	Extractor	Owner	Extractor	Owner	Extractor	Owner
Distribution of primary income account								
Gross rent	-49.7	49.7			-49.7	49.7	-49.7	49.7
Consumption of natural capital						-29.4		-12.8
Net rent			-20.3	20.3		20.3		36.9
Capital account								
Capital transfer			-29.4	29.4				
Other changes in assets account								
Depletion		-29.4		-29.4				
Discoveries		16.6		16.6		16.6		
Revaluation		22.9		22.9		22.9		22.9

Source: SEEAland data set.

Assets recorded in the user's balance sheet

10.95 In the case of financial leasing, a produced asset is recorded in the balance sheet not of the legal owner but of the user. The conditions are that the legal owner, usually a financial institution, has no productive activity for which the asset would be relevant. Nor does the legal owner assume any responsibility for the use of the asset nor for its care and maintenance. All these are assumed by the user. The view is that there is a de facto transfer of ownership to the user in return for which there is a financial claim and liability established between the owner and the user. Payments from the user to the owner are treated as being in part the repayment of the financial claim and in part the payment of property income, but in this case they are treated as interest, for the use of the asset by a unit other than the owner. More detail on financial leasing can be found in the 1993 SNA (paras. 6.118, 6.119 and 11.31).

10.96 It has been suggested that there are cases where non-produced assets are put at the disposal of the user in conditions similar to financial leasing and so a similar form of recording would be appropriate. An obvious case is where an extractor of a subsoil deposit is given the right to exploit the deposit to exhaustion or at least for an extended period of time. It is the extractor who makes the decision about the rate at which the stock is depleted and is responsible for all aspects of the extraction process. The return to the deposit and its depletion are recorded in the extractor's accounts in accordance with the procedure in the case when the extractor is the owner.

10.97 If this position is adopted, the consequences for the flow accounts are that the actual payment from the user to the owner has to be partitioned as in option E2 above, but now the capital part is regarded as a financial transaction rather than a capital transfer and the property income flow consists of interest rather than of rent.

10.98 One unsatisfactory aspect of this option is the fact that the changes in the value of the deposit resulting from changes in relative prices, from new discoveries and from changes in the extraction rate all affect the level of the financial claim and liability as well as the value of the mineral deposit itself. This is a most unusual situation for financial assets which are usually clearly specified at the time they are acquired and not subject to such fluctuations. These fluctuations also have implications for the partitioning of payments into a capital and an income element.

10.99 Table 10.3 gives an example of how the changes in the financial liability might be calculated. The starting point is to calculate the level of the financial liability at the start of the year. This is assumed to be the fraction of the stock of the resource (estimated as described in chap. VII) represented by the owner's share in the resource rent in the previous year. The value of the stock at the end of the year is calculated in the same way as before. A new value of the financial liability is calculated according to the owner's share of the current year's resource rent. The change in the financial liability over the year is then calculated as the difference between the figure at the start and the figure at the end of the year.

Table 10.3. Illustrative example of imputing change of ownership for a financial liability

Billions of currency units

	Total	Extractor	Owner
Stock at end of previous year	698.8		
Resource rent allocation previous year	49.1	3.7	45.4
Financial asset/liability end of previous year		-646.2	646.2
Change in resource stock due to			
Extraction	-29.4		
Discoveries	16.6		
Revaluation	22.9		
Stock at end of current year	709.0		
Resource rent allocation current year	58.3	8.6	49.7
Financial asset/liability end of current year		-604.9	604.9
Change in financial asset/liability			-41.3

Source: SEEAland data set.

Assets shared between the owner's and user's balance sheets

10.100 The possibility exists of treating the asset as being part owned by more than one unit, with these units possibly falling in different institutional sectors. If this is so, then there will be two sets of entries, one relating to the user in respect of his share of ownership of the asset and the other relating to his payments to the owner in respect of the owner's share of ownership. The latter may follow any of the options described above for outright ownership of the asset.

Stock level and owner unknown

10.101 The procedure just described, where there is full balance sheet accounting and the owner is known, is difficult to apply in cases such as that of uncultivated fish, where there may be little firm evidence of the level of the stock and where the government, even if it is the nominal owner, may not always receive a "royalty" or "rent" payment for the right to fish.

10.102 An alternative procedure suggested by Vanoli (1995) is to introduce a quasi sector for nature. Natural growth is shown as a resource of nature and adds to depletion-adjusted saving, though without affecting the depletion-adjusted saving of any other sector. In the balance sheet, this addition to stocks offsets some or all of the harvesting of fish which is shown as a gross extraction under the fishing industry.

Examples of accounts

10.103 Table 10.4 shows a more complete set of flow accounts than those presented earlier. It covers the whole economy consistent with option C2 and shows how the consequences of the adjustments to operating surplus affect subsequent balancing of items up to saving. Because of the adjustments in the capital account, however, net lending and borrowing are not altered by the changes in the recording of depletion. The figure for net lending for the whole economy remains 40 billion currency units which is the excess of exports over imports in the SEEAland data set.

10.104 The only items for property income flows and transfers included in the table are those necessary to maintain the integrity of the goods and services account. The accounts for each of the resource industries are consistent with the SEEAland accounts shown in chapter VII.

10.105 What is most striking about the table when comparing the various options is that the only decisions that affect the value of the macro aggregates are, first, the decision on whether to have some adjustment for depletion and, second, that on whether to show additions to stock levels in the transaction accounts. Once these decisions are made, although there are sector-by-sector differences in subsequent balancing items, for the economy as a whole differences cancel across sectors. Thus, the consequences for the economy-wide balancing items – from balance of primary income onward up to and including saving as well as domestic product and income measures – are the same whatever precise option is used to record the various flows.

C. Defensive expenditure

10.106 The issues of defensive expenditure and degradation are closely linked, since the former helps to prevent the latter. It is helpful to have a clear view of how defensive expenditure is and might be identified in the accounts before proceeding to consider the same issues for degradation.

10.107 As discussed in the introduction to this chapter, defensive expenditure is a term that can be applied to a wide variety of expenditures. The main discussion here concerns environmental protection expenditure which is an obvious candidate for inclusion. Other possible candidates for inclusion would be costs for regulatory bodies charged with protecting and managing natural resources and health costs incurred to mitigate the effects of atmospheric pollution.

1. Current and capital environmental protection expenditure

10.108 Measurement of environmental protection expenditure is discussed in chapter V. Expenditure that will help combat environmental degradation in both the current and future periods is classified as fixed capital formation. Regardless of what type of unit undertakes the expenditure, it forms part of final demand and adds to the level of GDP. As with all fixed capital formation, it is necessary to adjust for consumption of fixed capital in order to obtain a value for net domestic product or net national income.

10.109 Expenditure by producers that affects the level of environmental degradation only in the accounting period in question is treated as current expenditure, essentially compensation of employees and intermediate consumption. For all producers, expenditure not contributing to value added is recorded as intermediate consumption. However, when the producer is within the government sector and the production is for collective consumption, the environmental protection expenditure automatically adds to the level of government consumption and thus to the level of GDP. By contrast, for a producer who sells his products in the marketplace, intermediate consumption does not appear to add to GDP directly. This apparent asymmetry disturbs a number of commentators who suggest that all (current) environmental protection expenditure should be excluded from GDP.

Table 10.4. Illustration of depletion-adjusted flow accounts

	Flow accounts	Extraction of oil and gas		Forestry		Capture fishery		Aquaculture	
		Use	Resource	Use	Resource	Use	Resource	Use	Resource
	Production account								
1.	Output		133 167		2 444		6 642		6 434
2.	Intermediate consumption	19 124		826		2 863		5 438	
3.	**Gross value added**	**114 043**		**1 618**		**3 779**		**996**	
	Taxes less subsidies on products								
	GDP at market prices								
	Extended generation of income account								
4.	**Gross value added**		**114 043**		**1 618**		**3 779**		**996**
5.	*less* compensation of employees	6 738		413		1 390		431	
	less other taxes less subsidies on production	3 193		- 19		71		0	
6.	***equals*** **gross operating surplus**	**104 112**		**1 224**		**2 318**		**565**	
7.	*less* services of produced biological fixed capital								
8.	*less* services of other fixed assets	45 858		668		1 486		368	
9.	*plus* returns to produced biological fixed capital								
10.	plus returns to other fixed capital		20 938		290		516		128
11.	***equals*** **net operating surplus**	**79 192**		**846**		**1 348**		**325**	
12.	*less* harvest of natural biological resources			242		82			
13.	*less* extraction of subsoil assets	58 254							
14.	*plus* returns to natural biological assets								
15.	*plus* returns to subsoil assets		28 870						
16.	*plus* natural growth of biological assets				0		0		
17.	*plus* discoveries of subsoil assets		16 631						
18.	***equals*** **depletion-adjusted operating surplus**	**66 439**		**604**		**1 266**		**325**	
	Distribution of primary income account, Secondary distribution of income account, Use of income account								
19.	**Depletion-adjusted operating surplus**		**66 439**		**604**		**1 266**		**325**
20.	Compensation of employees								
	Taxes less subsidies on products								
	Other taxes less subsidies on production								
21.	Property income	45 500							
	Specific taxes on income from extraction	4 200							
22.	Consumption expenditure								
23.	**Depletion-adjusted saving**	**16 739**		**604**		**1 266**		**325**	
	Capital account								
24.	**Depletion-adjusted saving**		**16 739**		**604**		**1 266**		**325**
25.	Gross fixed capital formation	30 778		269		1 087		304	
26.	Consumption of fixed capital[a]	-24 920		- 378		- 970		- 240	
27.	Change in inventories			- 120				311	
28.	Land improvement			0					
29.	Harvest of natural biological resources[a]			- 242		- 82			
30.	Depletion of subsoil resources[a]	-29 384							
31.	Natural growth of biological assets								
32.	Discoveries and reappraisals of subsoil resources	16 631							
33.	**Net borrowing or lending**	**23 634**		**1 075**		**1 231**		**- 50**	

Source: SEEAland data set.

Note:

Row	Equals or is the counterpart to	Row	Equals or is the counterpart to row(s)
3	1-2	23	19+20 plus (resources) or minus (uses) 21-22
4	3	24	23
6	4-5	26	7+8-9-10
11	6-7-8+9+10	29	12-14
18	11-12-13+14+15+16+17	30	13-15
19	18		

[a] By convention, shown as negative use rather than as positive resource.

Millions of currency units

Other industries		Owner of subsoil assets (government)		Households		Nature		Total		
Use	Resource	Use	Resource	Use	Resource	Use	Resource	Use	Resource	
	1137 713								1286 400	1.
635 749								664 000		2.
501 964								**622 400**		**3.**
								70 000		
								692 400		
	501 964								**622 400**	**4.**
324 453								333 425		5.
755								4 000		
176 756								**284 975**		**6.**
140								140		7.
193 118								241 498		8.
	140								140	9.
	115 226								137 098	10.
98 864								**180 575**		**11.**
								324		12.
								58 254		13.
										14.
									28 870	15.
							263		263	16.
									16 631	17.
98 864						**263**		**167 761**		**18.**
	98 864						**263**		**167 761**	**19.**
					333 425				333 425	20.
			70 000						70 000	
			4 000						4 000	
			45 500						0	21.
			4 200						0	
		159 000		347 400				506 400		22.
98 864		**-35 300**		**-13 975**		**263**		**68 786**		**23.**
	98 864		**-35 300**		**-13 975**		**263**		**68 786**	**24.**
112 300								144 738		25.
-77 892								-104 400		26.
1 071								1 262		27.
								0		28.
								- 324		29.
								-29 384		30.
						263		263		31.
								16 631		32.
63 385		**-35 300**		**-13 975**		**0**		**40 000**		**33.**

Row	Equals or is the counterpart to row(s)
31	16
32	17
33	24-25-26-27-28-29-30-31-32

2. Environmental protection expenditure by government and industry

10.110 Gross domestic product can be measured by any of three routes and the accounting system in the SNA is such that each will give the same answer. The production measure counts all the goods and services that are produced, less those used for intermediate consumption. The expenditure measure counts the acquisition of the same goods and services to satisfy human wants. The income measure shows how the income generated in production is used to fund this acquisition of the goods and services produced. There is no automatic equality between all three measures for a single activity or group of activities: it holds in the aggregate only.

10.111 It seems relatively easy to consider excluding environmental protection expenditure by government since it can be identified within output and expenditure without a problem. However, it is difficult to make a case for to excluding the wages and salaries earned by, say, street cleaners and to classify these workers as unemployed on an "environmentally adjusted" basis. Their earnings are used to acquire goods and services for their families and there is no reason for, or obvious accounting means of, excluding these purchases and the subsequent consequences from the accounts. Simply omitting activities and preserving a closed accounting system are not an option.

10.112 Goods and services acquired by industry are not themselves part of final demand. They are incorporated into other products that fulfil this function after one or more further steps. Cotton is transformed into a fabric that is made into shirts, for example. However, the purchase of the shirt includes the cost of the raw materials that went into its manufacture. Firms that undertake environmental protection expenditure rarely if ever simply swallow the costs and take a drop in profits to pay for this. The usual market mechanism is to pass the costs on to their customers. Thus, those buying seemingly unrelated products will be paying an element which covers the cost of the environmental protection expenditure just as the buyer of a shirt covers the cost of the raw materials that went into producing it. It is thus an inaccurate simplification to think that, because a firm's environmental protection expenditure is counted as intermediate consumption, it does not add to GDP.

10.113 The accounting system makes no judgement about the moral worth or physical necessity of production. It simply records those products that are the subject of transactions in the marketplace and ensures that when these transactions are completely and consistently covered, the three measures of GDP will give the same answer.

10.114 The suggestion that the easily identifiable elements of defensive expenditure (environmental protection expenditure in this example) be removed from the expenditure side of the accounts is not tenable within a coherent accounting system. There is no way that, if this were done, exactly compensating deductions could be made from the other means of calculating aggregate GDP. Nor would this remove the whole of the designated activity.

3. A possible symmetric treatment

10.115 A symmetric treatment of environmental protection expenditure by government and industry cannot be achieved by simply omitting some part of the accounting system. However, we can achieve a form of symmetry by reclassifying some of the existing transactions.

10.116 Roads represent fixed capital formation. They are subject to extensive repairs and maintenance to maintain them in good condition. The 1968 SNA (United Nations, 1968) took the position that repairs and maintenance would be sufficient to ensure that a road lasted forever and thus there was no consumption of fixed capital allowance for roads in that version of the system. Gross capital formation was taken to be also a measure of net capital formation and all repairs and maintenance were treated as intermediate consumption.[33] There is another possible way to reach a similar position though, one which was in use in a number of Scandinavian countries before they adopted the 1968 SNA. This was sometimes known as the "gross gross" method of recording capital formation (Aukrust, 1994). Under this, all repairs and maintenance were recorded as part of gross capital formation and that part that would otherwise be counted as current repairs was treated as a form of consumption of fixed capital, thus eliminating the double counting just introduced.

10.117 The gross gross approach to recording current environmental protection expenditure is one way to achieve a symmetric treatment of such expenditure by government and industry. If the expenditure undertaken by an industry is treated as both capital formation and consumption of fixed capital, the level of output of the industry of its other products will not alter. GDP will increase by the amount of the environmental protection expenditure but net domestic product will not change. The change in classification of government environmental protection expenditure will not affect GDP, though some final consumption will now appear, instead, as fixed capital formation. On the other hand, net domestic product will fall by the amount of this expenditure just reclassified. In this way, we have a symmetric recording of environmental protection expenditure between industry and government and the gap between GDP and NDP is increased by the whole amount of this expenditure, by increasing GDP by the current expenditure by industry and reducing NDP by the current expenditure by government.

Environmental protection expenditure by households

10.118 As indicated in the example from chapter V, households also purchase environmental protection products. Simply reclassifying this household consumption as a form of capital formation seems to introduce quite a new concept in the SNA, the idea of capital formation without any associated production process. However, several types of collective consumption, including the environmental protection expenditure carried out by government, could be described as comprising capital formation not directly linked to production processes. At present in the SNA, only government undertakes collective consumption, but if the guidelines were relaxed to permit other sectors to finance collective consumption, this would allow household consumption on environmental protection expenditure to be reclassified as capital formation also.[34]

10.119 An illustrative example, based on the data for environmental protection expenditure given in chapter V, is provided in Table 10.5.

4. Implications at constant prices

10.120 It is important for policy analysis that the national accounts not only give a relevant measure of expenditure in current prices but also portray the pattern of economic growth in an analytically useful way. We therefore need to consider what happens to measures of growth when new environmental protection expenditure is undertaken.

[33] This position was changed in the 1993 SNA based on recognition of the fact that even with regular maintenance roads eventually need complete renewal. This is not the present point at issue though.

[34] This idea is further elaborated by Harrison (1999). It provides for a similar mechanism for reclassifying environmental protection expenditure by industry which is an alternative to the "gross gross" recording suggested above.

Table 10.5. Illustration of adjustments to GDP and NDP for defensive expenditure

Billions of currency units

	Output	Intermediate consumption	Taxes on products	GDP	Consumption of fixed capital	NDP
SNA totals	1 286.4	664.0	70.0	692.4	104.4	588.0
Ancillary production: addition	4.0	4.0				
Reallocations						
Intermediate consumption		-9.5			9.5	
Government final consumption					1.8	
Household final consumption					3.6	
Capital formation					0.1	
Defensive-adjusted totals	1 290.4	658.5	70.0	701.9	119.4	582.5

	Final consumption of government	Final consumption of households	Gross capital formation of households	Exports	Imports	GDP
SNA totals	159.0	347.4	146.0	403.0	363.0	692.4
Ancillary production: addition						
Reallocations						
Intermediate consumption			9.5			
Government final consumption	-1.8		1.8			
Household final consumption		-3.6	3.6			
Capital formation						
Defensive-adjusted totals	157.2	343.8	160.9	403.0	363.0	701.9

Source: SEEAland data set.

10.121 Although measures of national accounts at constant prices are sometimes referred to as being in "real" terms, they are in fact somewhat hypothetical. They attempt to measure the level of activity in one accounting period at the prices prevailing in another period. This makes sense only if the changes are fairly modest. If there has been a radical change in the structure of the economy or of relative prices, asking what the level of activity would have subsisted based on the other set of prices becomes a silly question and so does any answer other than, That type of activity would not have taken place at that set of prices.

10.122 Properly speaking, the expression "constant prices" is shorthand for a set of conditions. Not only price levels but the quality of goods, the technology of production and the tax structures are also supposed to remain constant. The issue of constant quality is discussed in chapter IV, where it is explained why volumes in the constant price terms of the national accounts are not necessarily the same as physical quantities.

10.123 If between period t and t+1, new environmental regulations are introduced that lead to significant new environmental protection expenditures, what is the effect in constant price terms? This depends on whether the increase in the current price value is seen as being purely a price increase or a quality increase. In practice, there are some such innovations that are generally treated as quality increases. The introduction of catalytic converters in motor engines is frequently cited in this regard. In some instances, though, and especially when environmental protection expenditure is undertaken as an ancillary activity not identified as suggested in chapter V, it is quite possible that the increases in costs appear as price increases. A discussion of some of the practical difficulties in identifying the difference between price and quantity effects is given in Steurer and others (1998).

10.124 For some analyses, it may be desirable to take the idea of constant prices one stage further and specify explicitly both the base year for the constant prices and the base year for the environmental standards. Measuring growth between years t and t+1, when there are different environmental standards in the two years, does not illustrate the impact on growth of perpetuating a given environmental standard. It may be more useful to consider a two-step approach. A comparison between year t at the prices and environmental standards of *t* and year *t* at the prices of *t* but the environmental standards of year *t*+1 would give the impact of changing environmental standards; then a comparison between year *t* assuming not just the environmental standards but also the prices of year *t*+1, and year *t*+1, would give a measure of growth at constant prices and constant environmental standards. For more on this, see Harrison (1997).

10.125 As pointed out by Steurer and others (1998), it may well be price statisticians who have made the decisions about when to treat environmental protection as a price increase so that national accountants and environmental accountants may not be able to determine what has been done. However, an option whereby all environmental protection expenditure was treated as gross capital formation would open the way towards making adjustments to explore the option of treating more of this expense as a quality change rather than as just a price increase.

D. Degradation

1. Alternative approaches

10.126 Incorporating the effects of degradation into the conventional economic accounts is more difficult, less certain and more controversial than making adjustments to the accounts for either depletion or defensive expenditure. The present section is therefore more tentative and longer and contains more radically different alternative options than the preceding sections.

10.127 If we have an asset that will last forever, providing the same services year after year, then the whole of the value of that service may be regarded as income. If there is deterioration in the asset so that either the level of the services declines or the life length of the asset ceases to be infinite, then the decline in the value of the asset must be regarded as a deduction from income.

10.128 In the case of the environment, there are services provided every year that are not currently given a money value. Until recently, the supposition was that these services would continue to be provided year after year without a decline in quality or quantity of the service. This is now put in doubt and the precautionary principle is invoked to protect the level of services the environment can provide in the future by restricting the extent to which the environment is used as a sink for residuals.

10.129 It should be recognized explicitly at the outset that information about degradation, even at a physical level, is much less well established than information about other environmental phenomena. Ways of documenting quality decline have still to be further developed and budgetary resources to measure it are not sufficient. There are not only theoretical but also serious practical problems in the way of assessing the impact of degradation reliably.

10.130 An ideal situation might be to consider that it is possible to value all environmental functions and to devise an eco-environmental aggregate that included the value of all economic products and all environmental functions. Impairment of environmental functions would then represent a deduction from a state where all environmental functions were preserved. Unfortunately, it is not possible even to specify all environmental functions exactly in quantified terms, let alone put a monetary valuation on each. A somewhat simpler and less ambitious target has therefore to be formulated.

10.131 Chapters VII and VIII deal with accounting for resource functions in both physical and monetary terms. Chapter III describes how physical flows of residuals can be associated with production and consumption processes. It is assumed here that it is the excessive generation of residuals that impairs the quality of environmental media and hence of the environmental functions they provide. Unfortunately, the exact links between specific residuals and a given environmental function are not always established and seldom quantified precisely. However, although we cannot value the environmental functions directly, we can investigate whether we can value the deterioration in air and water quality on the assumption that if this were reversed, the environmental functions that clean air and water carry out would be restored.

10.132 Alternative methods of valuing degradation were discussed in chapter IX. These were characterized as damage-based and cost-based. The consequence of having two valuation principles for measuring degradation is to have two sets of accounting adjustments, one flowing from each.

10.133 Damage-based estimates answer the question how much damage is caused by environmental degradation. Cost-based estimates answer versions of the question how much it would cost to avoid environmental degradation. Both questions have their foundation in the Hicksian concept of income as being dependent on preserving the value of one's wealth;[35] but one type of estimate is formed by looking at what has happened to the stock of assets (the damage-based estimates) and the other is based on a measure of income (the cost-based estimates). Both types of estimates incorporate hypothetical valuations into the economic accounting system and thus are less firmly based than measures depending solely on observation. Both are crucially dependent on the adequacy of the data on generation of residuals and environmental quality in physical terms, as described in earlier chapters.

10.134 The consequences of degradation on the stock of assets are easy to recognize in deforestation due to air pollution and land degradation caused by overlogging, for example. Similarly, it is possible to visualize damage to produced assets, for example, the damage caused to buildings and equipment by acid rain. More controversial in accounting terms is the damage done to human health, since this is not presently regarded as an asset within the accounting system. In broad terms, damage-based adjustments follow the logic of depletion-type adjustments discussed in section B and are discussed first.

10.135 The cost-based alternative is more like an extension of defensive expenditure and is essentially an income approach. When it is associated with the notion of maintaining environment services within the existing economic structure, this results in the so-called maintenance cost approach.

10.136 The maintenance cost approach implies imputing values of costs and activities that either do not take place in fact or have zero market value. Instead of wrestling with the accounting implications of this inherent inconsistency, one important alternative is to suggest that this approach starts from the wrong place. Instead of asking how much the value of GDP would be affected if the accounting system were changed to reflect the use of environmental media, it assumes that the accounting system is quite satisfactory as it stands and that the problem is to know how economic activity itself should be altered to reduce environmental degradation. This approach has come to be known as "greened-economy modelling".

10.137 Just as there was no automatic equality between damage-based and cost-based pricing techniques, so there is none between the alternative adjusted aggregates coming from the damage-based and cost-based approaches. Only by coincidence do the costs equal benefits or avoided damages. If we realize the links of the two with the wealth and income approach, we can acknowledge that what we have is an accounting inconsistency between the measurement of stocks and that of flows in the system. However, comparing the two estimates is useful. For example, by assessing the cost of achieving given environmental targets, the goals can be adjusted according to what is considered a reasonable estimate of benefits. The consistent application of these two approaches leads to two different environmentally adjusted macroeconomic aggregate measures which are to be interpreted differently. They serve different policy purposes and lead to different analyses. Rather than make a choice between them, one should see them as complementary and as often developed in parallel.

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[35] "Thus we may say that income is the amount a man can spend in a week and still be ***as well off*** at the end of a week as at the beginning" (Hicks, 1946).

2. Damage-based methods to derive macro-aggregates

The measurement of damage within the SNA

10.138 A cost-benefit analysis of the impact of environmental pollution would suggest that costs to avoid pollution would be incurred up to the point where the benefits were at least as great as the costs. One problem is that, often, the costs will be incurred by one set of economic units and the benefits will accrue to another set. Typically, therefore, the users of environmental resources continue to regard these as "free" and thereby impose disbenefits or damages on other units. (These are the effects that economists refer to as externalities.) Chapter IX examined how damages actually incurred and benefits forgone might be valued.[36] The present section examines how these values might be brought within the flow accounts in order that "damage-adjusted" aggregates might be derived.

10.139 Damage from environmental degradation may manifest itself in a number of ways. It may result in or affect actual transactions that are recorded in the accounts leading up to the calculation of GDP or in subsequent adjustments to reach depletion-adjusted domestic product (dpNDP). For simplicity's sake, these are referred to here as damage-affected transactions. Environmental damage may affect the conditions and thus the value of man-made assets and environmental assets, both those within the economic asset boundary of the SNA and those added in by the SEEA. These are described as damage-based valuation adjustments. Environmental degradation may also have detrimental effects on human health and on living organisms more generally. The impact on human health is probably the issue that has the highest profile in terms of the effects of environmental degradation. Most of this section is concerned with how a valuation might be placed on the effect on human health. Damage to other living organisms is noted but not directly addressed in the adjusted aggregates presented here.

Damage-affected accounting entries

10.140 Agriculture is the industry most obviously affected by environmental degradation. Livestock may have reduced growth rates owing to water pollution; forests and crops may suffer because of acid rain or reduced productivity of the land due to acidification. If plants or animals grow more slowly, reproduce less or die earlier because of environmental pollution, then this should in principle be reflected in the accounts and show up as lower increases (possibly decreases) in the stock of these assets. If these are cultivated biological assets, the value of output and value added will implicitly record this fall without further adjustment. If the biological assets are non-cultivated, the figure for natural growth of non-cultivated biological assets and the value of dpNDP will be lower than if there had been no environmental degradation.

10.141 More controversial is the possible treatment of disasters. Usually, in national accounts, floods, droughts and forest fires are treated as exceptional events whose cause is not human activity. Some of the more spectacular recent disasters, however, can be traced to human culpability. Excessive upstream deforestation increases the probability that heavy rains will lead to disastrous floods; uncontrolled slash-and-burn techniques may lead to major forest fires; overgrazing may lead to desertification. The possibility exists of considering the damage caused by such events, along with the effects of shipwrecked oil tankers, for instance, also as environmental damage. This issue is not pursued further here but is left as a marker for consideration.

[36] In the 1993 SEEA, these damage costs were referred to as "repercussion costs".

Damage-based valuation adjustments

10.142 When market prices for the assets do not exist, the values are determined to be the net present value of future income streams. When market prices do exist, their determination is supposed to be consistent with this hypothesis. Insofar as damage caused by environmental degradation affects the services to be rendered by assets, whether produced or non-produced, and is likely to continue to affect these services in the future, in principle, this should be reflected in changes to the value of these assets.

10.143 The simplest example concerns the value of agricultural land. If the crop yield has declined because of degradation and is expected to be lower than its potential in future for the same reason, the market value of the land should fall to reflect this. Buildings and structures may suffer damage due to acid rain and pollution. Urban residential buildings may lose value because of increasing noise due to urban congestion. If the damage done to buildings or equipment is such that their efficiency is reduced or their useful life is shortened, then the changes in the value of the assets in the asset accounts should reflect this. The 1993 SNA recognizes this and mentions it as "degradation of fixed assets not accounted for in consumption of fixed capital" which is part of the item for other volume changes to be recorded in the other charges in volume account (see para. 12.45). Within the SEEA, it would seem logical to treat this in a similar way to that for the consumption of natural capital, as discussed in section B.

10.144 One position is that these changes should be noted and recorded as part of consumption of fixed capital, since this represents the decline in value of the asset during the year in question. An alternative view is that the decline in value is due to an external event not directly related to the use of the asset, and thus should be recorded separately. If this is done, it should be recorded in the other changes in assets account. In drawing up environmental accounts, the compiler should find out whether these effects are already counted in consumption of fixed capital and, if not, whether an estimate is already made and included in the other changes in assets account or whether a new adjustment needs to be calculated. If the new adjustment does need to be calculated, it should also be incorporated in the regular SNA accounts, since it affects the articulation of the accumulation accounts from opening to closing balance sheets. Note that if environmental standards are improving, it is possible that historically based life lengths and efficiency factors may be too pessimistic and a reduction in consumption of fixed capital would be appropriate.

Damage to human health

10.145 The present SNA has no means of taking the damages to human health caused by pollution into account through the consideration of assets. One possibility is to consider introducing human capital into the balance sheet and thus regarding the health damage as another form of reduction in the nation's net worth. While this approach has some appeal, it is not wholly satisfactory. At best, one could estimate the change in human capital due to changes in health but not the total value of human capital. Placing a monetary value on the damage caused by disease does not necessarily lead to valuation of a healthy life. Nor is health the only factor affecting a valuation of human capital: education is another obviously relevant factor. If human capital is taken to be the people employed in production, how useful would a measure of environmental damage be that ignored damage done to children and the elderly because they are not of working age?

10.146 The alternative route is to revert to the question of welfare. This is by no means intended to be a comprehensive measure of welfare but simply one that says that a deterioration in health represents a deterioration in welfare that many people would be prepared to pay to avoid if possible. In this sense, therefore, we may say that from the income generated from production we should deduct not only the allowance for depreciation of fixed capital which is part of conventional national accounts, and the allowance for depletion of natural capital discussed in section B, but also a sum representing the decline in welfare caused by environmental damage.

10.147 This approach introduces concepts and practices that represent major innovations with respect to the SNA as currently articulated. The benefits we receive from a good state of health are not recorded in NDP, yet we suggest recording a decline in those benefits due to environmental degradation as a decline in NDP. If we were to suppose that a (restricted) value of welfare could be estimated as being the sum of NDP plus a health benefit H, then we could more easily say that the decline in welfare due to environmental degradation was the decline in the original sum NDP+H. This is not possible as long as we have no robust estimates of H. However, it means that, in looking at the impact of degradation, it is advisable to relate it to year-to-year changes (when the unknown value of H may be fairly constant) rather than to just a simple comparison with the absolute level of NDP.

10.148 This problem is not new and has frequently been commented on in the context of the controversy over whether so-called defensive expenditures should be deducted from NDP. If damage occurs and is remedied, the cost of the remedy forms part of the economy and the activity involved directly or indirectly adds to national income. Preventive services, such as fire services, also contribute to national income because they provide employment, even though the goal is not to have to fight fires, or, if fires occur, to minimize the damage caused. What is currently included in GDP for these services is the cost of providing them, not a "welfare" value of the protection they provide. Before deducting the damage caused by a fire, in principle the benefit of a "fire-free" economy should be included.

10.149 In chapter VII there was discussion of the various services provided by the environment and a distinction made between use and non-use values.

> Use values refer to the direct or indirect use values of environmental goods, for example, timber revenues or recreation. Use values also include the option values that express the preferences that individuals have for an asset or service they might use in future as well as bequest values that signal preferences for preserving an environmental asset or service for others, including future generations.
>
> Non-use values cover only existence values (or intrinsic values) that signal preferences individuals have for some good they may never actually or potentially use, for example, the preservation of some species, ecosystem or habitat.

10.150 As can be seen, the damage-cost approach does not attempt to put a value on the total services rendered by the environment. All existence values and many indirect use values are left out, though some of the techniques described in chapter IX could, in principle, be used to widen the extent of the services covered to encompass, for example, the recreational services provided by the environment and other services.

Damage-adjusted product and income

10.151 In the absence of property income flows to and from the rest of the world, net domestic product and national income are the same. Since at the moment the flows with the rest of the world are not our main concern, we consider the move from production to income assuming these flows are zero.

10.152 Damage-adjusted income is the damage-based income measure coming from the SEEA. It is derived as follows.

GDP (gross domestic product)

less consumption of fixed capital

equals NDP (net domestic product)

less any damage adjustments to asset valuation not included in consumption of fixed capital

less depletion of natural resources

equals dpNDP (depletion-adjusted NDP)

equals depletion-adjusted national income

less pollution damage to human health

equals daNNI (damage-adjusted national income)

10.153 ***Consumption of fixed capital*** is the standard national accounts measure. As explained above, if it does not include the effects of pollution damage on economic assets, then a separate adjustment should be made for this damage.

10.154 ***Depletion of natural resources*** should be calculated as explained in section B. It should measure net depletion of biological resources that have an economic value. It could include a net increase in the value of subsoil assets if the increase in economic rent of those assets through discoveries exceeds the higher economic rent of the amounts extracted in that year. A key point is to avoid counting losses in current production as a change in asset value. For example, acid precipitation may produce a loss in agricultural production in a given year but this loss is already captured in GDP in the sense that agricultural output is lower than it would have been in the absence of the pollutant. However, if this acid precipitation reduced soil fertility in a permanent (or at least long-lived) manner, then this should show up also in the asset accounts as present values of lost land rents.

10.155 ***Pollution damage to human health*** covering both pollution-linked morbidity and excess mortality needs to be valued (using combined dose-response and willingness-to-pay methods, as described in chapter IX).

10.156 Damage-adjusted income clearly says something about the country's revenue-creation capacity under prevailing conditions (including market, political and institutional as well as environmental conditions). This figure of Hicksian income for a country, as for any firm, is basically an accounting result in the sense that it gives an evaluation of the performance of the firm (or country) during the current year, calculated with current-year prices.

10.157 Analysts should resist the temptation to use this Hicksian income as a hasty estimate for "sustainable national income" (SNI). If we continue with the analogy of a firm, the Hicksian income for a firm is "sustainable" only if the prevailing prices and external conditions for the firm do not change for the time-horizon of interest. If the conditions change in any ways that are not already "internalized" into these prices and asset valuations, then the Hicksian income as defined for the current period does not provide a reliable guide as to future viability (for better or worse) of the enterprise.

10.158 Damage-adjusted income can give a useful impression of the direction in which a country is headed and may be a very powerful indicator of problematic trends. However, this "diagnostic capacity" does not, in itself, tell where a remedy might be found. This issue and a potential solution are discussed further below.

Damage-adjusted saving

10.159 Hicksian income is usually defined as the maximum consumption obtainable while maintaining the total capital stock intact. Since income is equal to consumption plus saving and net new investment equals saving, income will be a measure of Hicksian income only if saving is positive or, at least, not negative. Just as we defined damage-adjusted income above, we may define damage-adjusted saving. It is either damage-adjusted saving = damage-adjusted income

less final consumption by households and government

or it can be derived from saving as measured in the national accounts less the same adjustments made to obtain damage-adjusted income from GDP.[37]

10.160 Damage-adjusted saving is a particularly intuitive indicator, since a value less than zero gives a clear warning that stocks of assets are being run down and that the economic situation cannot continue in the long run without a reversal of this position.

10.161 Obviously, the figures for both damage-adjusted income and damage-adjusted saving are sensitive to the categories of assets included. It is essential, in order to avoid misunderstandings, to present clearly what is, and what is not, included in the set of economic and environmental assets being considered. What is or should be included in a country's damage-adjusted income may be determined by the circumstances governing what is deemed most important or what it is feasible to estimate. As the set of assets includes changes, the "damage-adjusted" aggregates will change. In particular, attempts to include climate change, biodiversity, land cover change or other aspects of environmental services not yet monetized might provide key opportunities for highly fruitful explorations of the policy applications of the SEEA 2000 framework.

Environmental debt

10.162 In making adjustments to current-period production or income measures for degradation, it is clearly only appropriate to adjust for degradation caused in the present period. This should include an allowance for pollutants generated this period even though the effects may not be felt until later, but should not include the costs of repairing damage caused in an earlier period. As noted earlier, unremedied degradation that carries forward to a future period is sometimes referred to as "environmental debt". Knowing the extent of this "debt" is obviously useful, but it is a stock value rather than a flow. As with asset accounts, it is possible, in theory at least, to track this through time, seeing how much debt is ameliorated in a year and how much is added to the debt. As with other entries in the balance sheet, the costs of restoration are likely to increase over time also, hence there is a type of "holding loss" associated with environmental debt.

10.163 For additions to environmental debt, increments to stock pollutants should be valued as the present value of damages resulting from these increments over their lifetime in the environment. This is the methodological basis for the damage figures that are estimated for CO2 emissions, for instance, where a 200-year residence time in the atmosphere is assumed.

10.164 In looking at the value of existing environmental debt, it should be noted that not all environmental assets can be restored because of irreversibility. Available restoration methods often restore the environmental asset, or reduce the environmental debt, only to a certain extent.

"Repaying environmental debt"

10.165 If the level of environmental protection in a year not only is sufficient to keep the level of residual generation within the assimilative capacity of the environment but actually goes further and

[37] The concept of damage-adjusted saving as used here is closely related to the concept of genuine saving as used by the World Bank. Note, though, that the World Bank's use of the term "genuine saving" includes reclassifying current education expenditures as investment rather than consumption. This is not an issue of environmental accounting per se, but plays an important role in informing decision makers about the total change in the asset base underpinning development.

improves the situation by countering some of the past activities, this excess should be regarded as a form of capital expenditure offsetting part of the previous level of environmental debt.

Importing environmental damage

10.166 If one is thinking of making adjustments to the production measure of output in respect of damages, the correct figure to take is that corresponding to the damage due to generation in the national economy. If, on the other hand, one wants the effect on income, it is the net amount received which is relevant. Just as national income departs from national product by the amount of net income flows to and from the rest of the world, so this is the appropriate adjustment to make in respect of damage costs.

3. Cost-based methods to derive macro-aggregates

10.167 Actions that may be taken to prevent environmental deterioration or to restore environmental quality include:

(a) Reducing, or halting, harmful economic activities;

(b) Producing and consuming less harmful products;

(c) Changing to more environmentally benign technologies of production;

(d) Reducing the effects of current technologies by, for example, installing end-of-pipe scrubbers;

(e) Restoring environmental quality.

10.168 The ways of measuring the costs associated with these actions were described in chapter IX. The heading of avoidance costs covers structural adjustment costs (corresponding to (a), (b) and (c) above) and abatement costs (d), while the heading of restoration costs covers (e). The present section considers how these costs, if incurred, would be reflected in the macroeconomic aggregates. The method suggested in the 1993 SEEA, and implemented in a number of countries since then, relies on the maintenance cost approach.

10.169 As noted above, there are accounting inconsistencies implicit in the maintenance cost approach and a number of countries have adopted an alternative, modelling, approach to the question, usually called greened-economy modelling. This assumes that the problem of degradation should be addressed not via the accounting system but via economic behaviour. Each of these approaches is discussed below.

The philosophy of maintenance costing

10.170 Increasingly, more and more firms are incurring actual costs to mitigate their impacts on the environment, as a result either of governmental legislation or, simply, of pressure from a general public favouring producers seen to be “green”. For example, as the negotiations related to the Kyoto Protocol to the United Nations Framework Convention on Climate Change (United Nations, 1997b) on climate change have illustrated, corporations, with or without government intervention, are, increasingly taking many initiatives in respect of reducing CO_2 emissions in anticipation of future market intervention, to improve their image or to realize resource-saving potentials. These actual costs are captured in the type of accounts discussed in chapter V. This section is concerned with trying to evaluate the costs associated with environmental degradation that is not - or not yet - being controlled.

10.171 The objective of the maintenance cost approach is to try to estimate what the accounting entries would have been for the same level of activity if all the costs associated with environmental degradation had been incurred and internalized within market prices; in other words, it is an attempt to put a value on environmental sink functions that are currently free. As such, it is a hypothetical exercise and should be interpreted as such rather than portrayed - as is sometimes the cases - as a “correction” to the standard national accounts. Indeed, various levels of adjustment can be calculated depending on how much or how little degradation is to be permitted under the hypothetical scenario. It is sometimes unrealistic to assume that no degradation at all takes place and this is unnecessary in any case when there are natural assimilation processes at work to absorb some of the emissions.

10.172 Maintenance cost is sometimes interpreted as a proxy for the value of the environmental functions that are used up. Under this latter assumption, allocating the costs to those who cause the deterioration in the function is in accordance with the polluter pays principle and may suggest the level at which market instruments for cost internalization could be set.

10.173 Another possibility is to regard maintenance cost as a proxy for the environmental damage caused by economic activities during the accounting period. This perspective is behind the assumption that the value of the maintenance cost represents the “wear and tear” on the environment, just as the consumption of fixed capital represents the wear and tear on produced assets, and like the consumption of fixed capital, should be deducted from GDP in order that a measure of net domestic product or income may be reached.

10.174 Under either scenario, maintenance costs could be held to provide a snapshot of the immediate environmental impacts of economic activity without entering the realm of modelling. This assumption is more likely to be valid at the microlevel (than at the macrolevel) and when the decline in environmental quality in question is modest. The further the economy is from the desired environmental standards, the larger the adjustment and the less realistic this snapshot will be.

Measuring maintenance costs

10.175 The 1993 SEEA first defines maintenance costs as those “that would have been incurred if the environment had been used in such a way as not to have affected its future use” (United Nations, 1993b, para. 50). In fact, this position is somewhat modified just a few paragraphs later when the calculation of maintenance cost is described in a manner parallel to that of the consumption of fixed capital, that is, maintenance cost is set at the value of the costs that would have had to be incurred to remedy the environmental degradation caused by current production and consumption practices in the year. If the environment was in a perfect state at the start of the year, these two formulations would correspond. If, however, the environment is already impaired at the start of the year, the initial definition is overstated.

10.176 Maintenance costing is the only method described in the 1993 SEEA and in the associated operational manual (United Nations, 2000a) for deriving alternative macroeconomic aggregates. In those manuals, the term EDP is used for the concept described here as eaNDP (environmentally adjusted NDP). Although the definition used implies that no environmental degradation is allowed when using maintenance cost methods, in fact it can also be applied to a given environmental standard which may be less than perfectly clean.

10.177 The different ways of combating degradation imply different costs and different accounting impacts for each.

10.178 ***Avoidance costs: structural adjustment option.*** One approach might be to stop using fertilizers and pesticides, which would lead to a reduction in intermediate consumption but also to a greater reduction in output. GDP would therefore be lower than previously. Further, if the fertilizers and pesticides are domestically produced, there are likely to be second-round effects further reducing GDP. Another possible means of reducing environmental damage is to change from environmentally damaging products and technologies to more environmentally benign ones. Here the impact on GDP will depend in the main on the relative cost of the more benign products compared with that of the formerly used products.

10.179 ***Abatement and restoration costs***.[38] These do not involve cessation or change in activity but rather the embarking on new activity to either inhibit the production of pollution or to clean it up once it has taken place.

10.180 In general, structural adjustment costs lead to decreases in NDP, while those for abatement and restoration costs lead to increases. Restoration costs may be associated with a variety of causes, including natural events, domestic economic activities in the past or economic activities in other countries. They may also be spread over several time periods if actually carried out. Avoidance costs refer to the present emissions and to domestic economic activity. (Either, if actually carried out, may produce benefits in the future.)

10.181 In preparing estimates of costs, the choice of activities for calculating the maintenance costs depends on relative costs and efficiencies, that is, on best available technologies. Avoidance costs of industries should thus be based on the most efficient methods for not degrading the environment or for meeting environmental standards. Such standard-setting is in line with the more practicable approaches to approximating optimal tax rates for cost internalization (see, notably, Baumol and Oates, 1971). Restoration costs need to be carefully attributed to the current emissions and the anticipated effects of emissions discharged during the current accounting period. This is to ensure that environmental costs refer to the current wear and tear of natural capital and not to past environmental degradation.

10.182 In practice, even the best available technologies applied to current production and consumption processes may not always be capable of abating all the emissions generated during the accounting period. The remaining emissions would have to be "tolerated", as their removal would be suboptimal (owing to marginal costs exceeding social standards) in simulated markets. It is often assumed, or simply hoped, that these remaining emissions are safely absorbed by the environment, or are within the set standards. If this is not acceptable, the cost of avoiding the polluting activity altogether, in order to meet a given standard, has to be estimated.

10.183 Care must be taken not to use both avoidance and restoration costs, such as those for reducing acidifying pollutants at the source and counteracting the acidifying effects of the current year's emissions by liming, that refer to the same environmental damage.

Accounting for maintenance costs

10.184 A maintenance cost-based measure of eaNDP can be described as the attempt to answer the question, what would the value of net domestic product be if hypothetical environmental standards were met using current costs and current technologies?

10.185 Box 10.9 shows in schematic form a number of variations on the production account. The following symbols are used in the box:

P: production (output)

IC: intermediate consumption

M: maintenance costs

CFC: consumption of fixed capital

[38] The 1993 SEEA used the expression "repercussion costs" to cover costs due to environmental damage that has not been restored. In this manual, such costs are treated under damage-based estimates as described in chapter IX.

D: depletion

dpNDP: depletion-adjusted NDP

eaGDP: environmentally adjusted GDP

eaNDP: environmentally adjusted NDP

Box 10.9. Options showing the derivation of domestic product measures

	Gross domestic product	Net domestic product	
Option F1	GDP = P - IC	NDP	= GDP - CFC
Option F2	GDP = P - IC	dpNDP	= GDP - CFC - D
Option F3	eaGDP = P - M - IC = GDP - M	eaNDP = eaGDP - CFC - D = GDP - CFC - D - M	
Option F4	eaGDP = P - (IC + M) = GDP - M	eaNDP = eaGDP - CFC - D = GDP - CFC - D - M	
Option F5	eaGDP = P + M - IC = GDP + M	eaNDP = eaGDP - CFC - D - M = GDP - CFC - D	

10.186 The row for option F1 in Box 10.9 shows the standard SNA derivation of gross and net domestic products with no allowances for either depletion or degradation of environmental assets. GDP is defined simply as output (P) less intermediate consumption (IC). NDP is equal to GDP less consumption of fixed capital (CFC).

10.187 The row for option F2 corresponds to the elaboration of accounts in section B where depletion is taken into account in the difference between GDP and NDP but no allowance is made for degradation. Depletion here includes the effects of extraction, natural growth, discoveries and return to natural capital as detailed in section B.

10.188 The rows for options F3 and F4 cover avoidance costs (M). Although they seem identical, option F3 is predicated on the assumption that production falls because some environmentally harmful activity has been halted, and in option F4, it is assumed that intermediate consumption increases to mitigate the environmental damage which would otherwise result. In both cases, as a result of these measures, it is assumed that no degradation takes place, so that GDP and NDP both show the same decrease.

10.189 Option F5 presents one approach to restoration costs. Here degradation occurs but is remedied in the same period by undertaking new "clean-up" activity. Initially, this leads to an increase in GDP but the increase is offset by the extra deduction made for degradation actually occurring. This approach is consistent with that proposed for the treatment of defensive expenditure given in the previous section.

10.190 Although options F3 and F4, on the one hand, and F5, on the other, result in different values of gross and net product, the difference between gross product and net product in all three cases is equal to CFC + D + M, that is, the consumption of fixed capital due to produced assets (as in the SNA), plus depletion as in section B plus maintenance costs.

10.191 All these options are schematic. None leads to balanced national accounts because the effects of changes to output and intermediate consumption on the final use categories are not shown. Nor are any second-round or subsequent effects allowed for.

10.192 More importantly, neither option F3, nor option F4 nor option F5 reflects economic behaviour in the light of changed circumstances: they are purely (incomplete) accounting constructs. Option F4 assumes that the producer bears all the costs, passing on none to the purchaser. Option F5 assumes the reverse, namely, that the producer absorbs none of the costs but passes on all of them. In neither case is there a true internalization of the costs with consequences for changing production patterns and prices. In option F5, there is no apparent change in demand in the face of higher prices. Neither option F4 nor option F5 allows for changing technology in the face of higher costs, explains where extra demand comes from and whether the economy has the capacity to provide it without running into capacity constraints, or adequately allows for residuals generated by households in terms of a production account, except by creating a notional industry with maintenance cost and negative output of the same size.

10.193 With respect to an analysis that involves calculating the maximum impact of increasing environmental protection, these problems may perhaps be temporarily overlooked. When national accounts are calculated at constant prices, the prices of one year are applied to the volumes of another without any assessment of change in supply and demand, the whole of the reconciliation of any inherent inconsistency falling to the measure of value added at constant prices. In some ways, therefore, this seems to represent a similar situation. However, constant price calculations are made when the difference in prices cause only marginal changes in the patterns of demand between the current and base year. For non-marginal changes, the correct response might well be that "at those prices, that pattern of demand simply would not have existed". For maintenance cost for environmental protection, a similar situation prevails. It is a technique that can be used to estimate the maximum total impact of a marginal change in environmental standards but extreme caution should be exercised if it is used to estimate the impact of a change so large as to trigger major behavioural change. It is more suited for estimating the effect of fine-tuning environmental standards than trying to calculate the effect of removing all causes of degradation.

Maintenance costing in practice

10.194 Since the publication of the first version of the SEEA in 1993, a number of studies have been conducted using this technique. Some of these are referred to in chapter XI and a detailed account of work carried out in the Philippines is included there.

The philosophy of greened-economy modelling

10.195 One motivation behind many of the calls for "green GDP" in the past was the belief that alerting policy analysts, by means of adjusting standard macroeconomic aggregates, to the fact that the economy was damaging the environment would be sufficient to provoke policy change to avoid this damage. There were, and are, many analysts who feel that this is unlikely to be sufficient and is not, in fact, the most helpful sort of information to make available to those policy makers concerned with protecting the environment. Rather than a green GDP, what is needed is a blueprint for a green economy. It is not the accounting conventions that need to be changed but economic behaviour itself.

10.196 This ties up directly with the criticisms of the maintenance cost approach articulated in the previous subsection. If environmental functions actually had a price on them instead of a hypothetical value, economic behaviour would change in a way that made more prudent use of functions now no longer free. This would lead to preferring economic activity that was increasingly more responsible in environmental terms. The means of achieving this change in behaviour are, as before, abstaining from damaging activities, making structural adjustments to behaviour, using abatement techniques and restoring damage done. The pricing techniques available are the same: it is the context in which they are applied that is different.

10.197 The search is not for a different, greener, value of GDP for the same economy (eaGDP), but for a value of GDP, derived according to normal economic accounting practices, that relates to a different economy - one that is "greener" in that it is on a more environmentally benign path. The value of GDP for the greener economy is called "greened-economy GDP" or geGDP. Moreover, interest is concentrated on the time series of geGDP rather than on point-in-time estimates, since improved environmental standards take time to implement and require continual review and adjustment even when implemented.

10.198 The information from the maintenance cost approach may form the starting point for such an exercise, but the accounting framework is used as a basis for modelling rather than for making one-time adjustments to a limited number of aggregates. The model is used to determine the responses to extra demand for environmental protection goods and services and to look at the consequences of increasing prices. It can also be used to investigate the effects of achieving environmental standards by reducing activities with a high environmental burden in favour of those with less. An important feature is that all aspects of the accounts are utilized so that, as far as possible, all feedbacks are captured in the model.

National income and greened-economy modelling

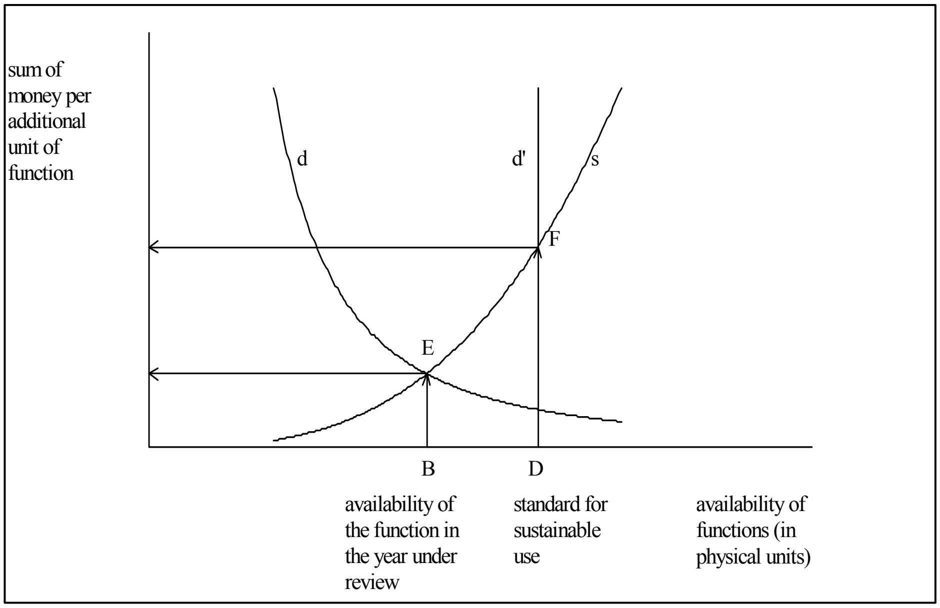
10.199 Much of the initiative taken in looking for an alternative path for the economy rather than for a different measure of the existing economy came from the work of Hueting in the late 1960s and early 1970s. He introduced the concept of environmental function referred to throughout this manual, explaining how pressure on functions leads to scarcity or competition for these functions. As with any economic good or service, this scarcity gives rise to an economic value due to the opportunity cost involved in its use or appropriation. The concern is then to define aggregate indicators to characterize a sustainable economy that ensures the maintenance of key environmental functions in perpetuity. Such an economy may be described as a "greened" version of the existing economy, where typically an increase in national income is secured at the expense of worsening environmental degradation. Interest then focuses not on the new aggregates themselves but on the gap between the existing economy and the greened version.

10.200 The choice in respect of the availability of functions for achieving a given end depends, on the one hand, on the quality, quantity and spatial extent of elements such as water, soil and life support systems, including ecosystems, which are largely amenable to measurement in physical units; and, on the other hand, on the strength of subjective preferences, which are not directly measurable. These considerations can be represented by a graph showing the availability of functions expressed in terms of a physical parameter on the x-axis and the strength of the revealed and unrevealed preferences as well as the costs associated with restoration and maintenance of functions on the y-axis (see Figure 10.1).

10.201 The marginal benefit curve in Figure 10.1 can in principle be constructed from the total of all expenditures, actually made or yet to be made, resulting from the loss of functions and of expenditures that people are prepared to incur to regain these functions.

10.202 Hueting postulated a partial measure of welfare that was derived from the conventional measure of income arising from economic activity by recognizing the disbenefits caused by scarcity of environmental functions. It refers to the maximum attainable national income given a set of assumed preferences expected to lead to the restoration and conservation of environmental functions. This indicator is called a greened-economy net national income (geNNI), using the terminology of O'Connor (2001). The concepts and their policy relevance have been explored in the context of the GREENSTAMP project (Brouwer and others, 1999). Applying proposed environmental standards as constraints on the national economy leads to the derivation of "greened" aggregates such as domestic product and national income using either comparative static or dynamic scenario modelling. Comparisons of these aggregates with the values actually measured in the economy as currently operating lead to measures of opportunity costs in the sense of consumption or investment options that would be necessary to pursue the chosen environmental standards. These standards may correspond to a measure of full sustainability or to a less stringent set of circumstances.

Figure 10.1. Translation of costs in physical units into costs in monetary units



Source: Hueting and de Boer (2001).

Note:

s: supply curve or marginal avoidance (or elimination) cost curve of the function

d: incomplete demand curve or marginal benefit curve based on individual preferences (revealed from expenditures on compensation of functions etc.)

d': "demand curve" based on assumed preferences for sustainability

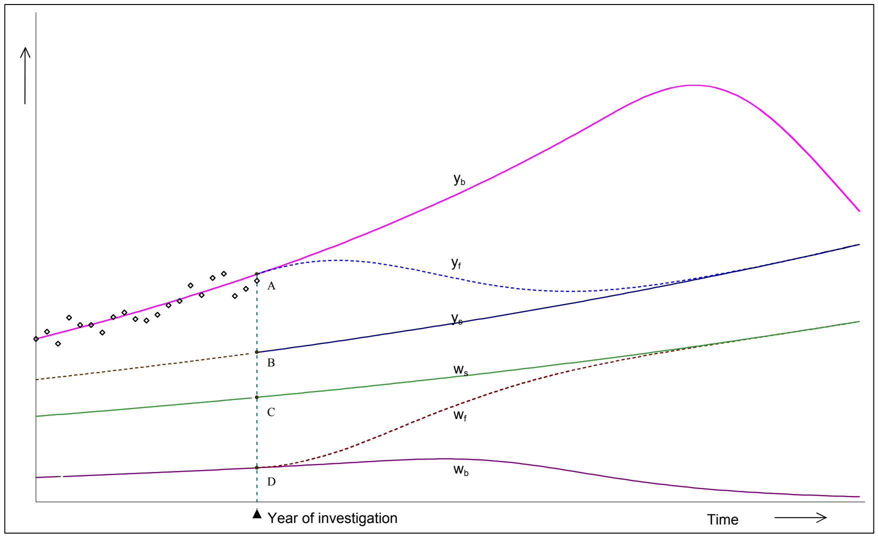
BD: distance that must be bridged in order to arrive at sustainable use of environmental functions

BDFE: costs of the loss of functions, expressed in monetary units

The arrows indicate the means by which the loss of environmental functions recorded in physical units is translated into monetary units.

10.203 Over time, as environmental pressures increased, the gap between conventionally measured economic welfare (as measured by national income) and the composite economic-environmental measure of welfare would increase and, eventually and inevitably, national income would decrease. This scenario can be seen in the top and bottom curves in Figure 10.2 which represent income (y_b) and welfare (w_b), respectively. Corresponding to this pair of curves, one can envisage another pair where the absolute level of income (y_s) is lower and the level of welfare (w_s) correspondingly higher under the assumptions made, but where income and welfare continue to increase without suffering the downturn of the first pair. The upper of these two curves corresponds to the notion Hueting called sustainable national income (SNI). It is the maximum income in a year in the past that can be sustained with the technology of that year, without assuming technological development except in respect of non-renewable resources. At a given point in time, national income is observed to be *A* and the corresponding welfare *D*. The corresponding SNI is B and matching welfare, *C*. Further details on this approach can be found in Hueting and de Boer (2001).

Figure 10.2. National income and welfare on three paths



Source: Hueting and de Boer (2001).

10.204 The two income lines passing through points *A* and *B* are so different that it is clear that they share few characteristics. Prices and levels of output differ and it is only possible to determine the parameters of the economy at *B* by applying a fairly complex model. It is obviously not possible in other than an analytical device to move instantaneously from *A* to *B*. One goal of the work is to derive an indicator for a given year in the past showing the extent of the environmental problems raised by production and consumption patterns of that year. Another goal is to project a transition path (y_f) from the non-sustainable income path to the sustainable one with a corresponding upward convergence (w_f) from the present welfare path to the sustainable one. A strategy to reach this path must take account of the institutional behavioural and information factors. This would mean that the desired environmental standards are currently breached. Planning this evolution in such a way as to manage a soft landing is at the heart of successful environmental policy.

10.205 Greened-economy modelling is a generalization of the SNI approach just described. As noted above, it is possible to specify less stringent environmental standards than those of full sustainability. Depending on how these are expressed, there is therefore an almost unlimited number of possible greened-economy paths and corresponding lines of income, each of which is sustainable only in certain environmental respects.

10.206 Just as it is possible to calculate a variety of income paths for different environmental standards, corresponding to generalizations of the pair of lines y_s and w_s, so it is possible to estimate a variety of transition paths by which to move from the existing economy lines (y_b and w_b) to any of these desired lines.

10.207 Greened-economy estimates may be calculated on the basis of historical data (ex post estimates such as SNI) or by using future projections (ex ante). They may be produced using a comparative static solution so that the estimates for each time point are derived independently from the others or a dynamic model which computes a continuous time path on the basis of changing stock variables. Together with the flexibility on the degree of implementation of sustainability to be applied in a greened-economy solution, there are three choices to be made about how a greened-economy solution is to be estimated. A description of a number of applications making different use of these three dimensions can be found in O'Connor (2001).

10.208 What distinguishes a greened-economy model from a more general economic model is the emphasis given to environmental improvement via economic processes. To achieve this, the following inputs are necessary.

10.209 The first entails establishing standards for the use of environmental functions such as those encompassing vital natural resources, environmental waste absorption capacities and life support systems, biodiversity, air, soil and water quality and the ecological dimensions of sustainability. This is done by means of modelling in physical terms as a result of which environmental standards are determined for use in succeeding stages of the model. These are specified through non-monetary targets relating to maintaining key environmental functions. Physical accounts are essential to organizing information concerning the state of the environment and key economy-environmental interface measures or environmental use or "pressure" indicators relative to estimates of environmental carrying capacities.

10.210 The next step is to identify the measures that would have to be carried out to secure the desired environmental quality level or measures for restoring environmental deterioration that actually occurred. Some specific examples thereof are:

(a) Expenditures by production sectors on behalf of using resources more efficiently or reducing polluting emissions per unit of output through changes in technologies;

(b) Shifts among different natural resources (for example, the use of wind power to replace the use of fossil fuel);

(c) Changing physical locations of environmental exploitation to make better use of local assimilation capacities;

(d) Replacing products or activities by alternatives less damaging to the environment, which involves changes in production and consumption patterns.

When the target path, such as a sustainable development path, is far away from the actual development path, the possibility of taking a lower human population into account has to be considered as well.

10.211 The third step is to calculate the costs necessary to implement these measures. Data on emissions, technology and costs are required to estimate aggregate abatement and restoration costs. Important sources of raw data are databases of technologies held by research institutes. Governments also increasingly collect physical characteristics and cost data of best available technologies for administrative purposes, such as the granting of authorization to operate installations (permits). An example of this trend is the reporting and information exchange mechanisms set up in Europe through the EU Council Directive 96/61/EC of 24 September 1996 concerning integrated pollution prevention and control (IPPC). Data from such sources are part of the first step towards standardization and increased comparability of environmental costing.

10.212 As explained, greened-economy indicators can be estimated using scenario modelling ex post for a series of years in the past or ex ante for years in the future. In Figure 10.2, ex post figures show a gap between geGDP that conforms to the assumed environmental standards in the year in question and the observed GDP. Ex ante projections start from a geGDP that is assumed to be already on a transition path. The figure for geGDP that results from the model will depend on the environmental standards chosen and also on demographic assumptions, hypotheses about preferences for future consumption patterns and the technological options being explored. A whole-economy approach must make explicit hypotheses about the timing of various policy and investment responses and the interdependence of the variables measured in the accounts. The aim is to model a scenario where the production and consumption of products generating high levels of residuals are reduced. This will have consequences for other industries related to high-residual producers and possibly on employment and household income. The scenario framework makes it clear that more than one greened-economy GDP figure or time series might be calculated, each connected to a different set of assumptions. There is no uniquely "correct" geGDP. On the contrary, different geGDP figures, or time series, give far more information to policy makers than one geGDP, provided that the assumptions underlying each of the variants are made explicit.

10.213 The definition and estimation of greened-economy GDP and NDP figures are intended to inform debate about alternative possible national economic development paths and trade-offs among output growth, final consumption and environmental performance objectives. Where the purpose is to investigate sustainability prospects, a robust and transparent approach is needed to develop ex post and ex ante scenarios based on explicit propositions about consumption, technological change, and environmental performance requirements.

10.214 In practice, it may often be the case that a definitive level of what is sustainable is very uncertain. However, the techniques above can be used to estimate the cost of reaching a given target, for example, those established under the Kyoto Protocol to the United Nations Framework Convention on Climate Change. In such cases, the costs calculated have a clear meaning (the cost of achieving the target). However, they cannot be interpreted strictly as the "cost of being sustainable" in absolute terms, but only as that of sustaining a given predetermined level.

Greened-economy modelling in practice

10.215 Some experience exists for making greened-economy estimates. Box 10.10 gives an indication of such experience in Germany. The extent of the data requirements was such that the researchers turned to modelling as a cost-efficient way of pursuing their objectives.

E. Summary

10.216 The present section examines the consistency of the various options presented; discusses theoretical, practical and institutional considerations; and assesses the impact in terms of quantification of making adjustments for depletion, defensive expenditure and degradation.

1. Depletion

Theoretical considerations

10.217 The section on depletion concerned the use of natural resources within production. By extension, it might have included reductions in the value of land and non-cultivated biological assets as well as reductions in value of produced capital brought about by the effects of environmental degradation.

10.218 Section B described various means of measuring depletion-adjusted income and depletion-adjusted capital formation in such a way as to make these two concepts strictly consistent with one another. The changes in capital stock are consistent with those recorded in an SNA asset account. By situating some items appearing in the SNA other changes in assets account within the income accounts instead, a matching measure of income can be calculated.

Box 10.10. Experiences of Germany in implementing the maintenance cost approach

> As a member of the European Commission-funded GREENSTAMP project, the German Federal Statistical Office applied and tested the maintenance cost approach of the 1993 SEEA during 1995-1997. The aim was to clarify the theoretical background of imputed abatement or avoidance costs, to develop a calculation procedure consistent with the statistical framework of national accounting, and to test the concept empirically by calculating abatement costs for the German economy for different nitrogen compounds (reporting year 1990 for the former Federal Republic of Germany). The final report discusses definitional, conceptual and empirical difficulties in the calculation of abatement cost curves. A multi-stage calculation procedure was developed allowing the aggregation of physical and cost data at the technical level in successive steps: first to the microeconomic level, then to the industry level and finally to that of macroeconomic abatement costs.
>
> Within the project, reliable abatement costs were calculated for the industry level, reflecting direct abatement costs at an industrial branch level for certain technical measures reducing emissions of nitrogen. Indirect physical and monetary effects were not calculated. Empirical experience gained through the project underlined the need for econometric modelling procedures to integrate such important indirect effects, mainly monetary, and arrive at comprehensive abatement costs in a macroeconomic perspective consistent with the framework of national accounts.
>
> In a subsequent step, following the GREENSTAMP philosophy, econometric model calculations were conducted in Germany by research institutes in collaboration with the Federal Statistical Office in 1997-1998. The macroeconomic consequences of meeting predefined environmental performance standards (for example, certain CO_2 reduction rates) were estimated. In that context, the database of the PanthaRhei (everything in flux) model of Osnabrück University was substantially enlarged by incorporating the detailed emission accounts of the Statistical Office and the abatement cost data of the GREENSTAMP project.
>
> Another research project examined the suitability of five major German econometric models for analysing changes aimed at a better environmental interaction. The general task was to determine the extent to which models are suitable for describing the actual state or pathways of a national economy while meeting given environmental targets or standards.

Sources: Radermacher and others (1998); Riege-Wcislo and Heinze (1998); and Frohn and others (1998).

10.219 Measures of gross and net domestic product with the same values as in the SNA remain in the accounts but an additional item, termed depletion-adjusted domestic product (dpNDP), is also presented.

Consistency of options

10.220 The key decisions to be made about whether to calculate a depletion-adjusted value of income are two. The first decision is whether to recognize any of the income arising from the use of assets as actually a reduction in national wealth that should be deducted from income. If not, there is no further deduction from NDP to be made to reach dpNDP. The second decision is whether to include any of the benefits from using natural assets as income from production. If not, then dpNDP is less than NDP by the whole of the value of the natural resources brought into the economy. The more general case lies between these two positions with some, but not all, of the value of the resource being treated as income and some as consumption of natural capital.

10.221 The global estimates for macroeconomic aggregates are unaffected by issues of ownership of the assets but section B spelled out various possible alternatives for recording the flows between the user and the owner. These are summarized in Box 10.7 and Box 10.8.

Practical considerations

10.222 All the calculations that need to be incorporated in the flow accounts are included in the steps necessary for calculating an SNA asset account for the natural resource in question. A summary of the parameters needed is given in Box 7.2.

10.223 It is worth noting that the size of any addition to or reduction in a reserve with a life length over 20 years and a discount rate greater than 5 per cent is relatively small and becomes even less significant as the life length and the discount rate increase.

Institutional considerations

10.224 Since the basic steps of the calculations are required in order to implement the SNA, there are no institutional considerations beyond deciding whether the use of natural resources is sufficiently important for the country to warrant making alternative presentations available to the general public. For some resources, there may be a question mark associated with the accuracy of the estimates which would caution against publication but in these cases the SNA cannot be fully implemented either.

Impact of adjustments on macroeconomic aggregates

10.225 The example for the SEEAland data given in Table 10.4 shows a figure for GDP of 692.4 billion currency units. This is reduced by 104.4 billion currency units in respect of consumption of fixed capital to yield a figure for NDP of 588.0 billion currency units. If an adjustment is made in respect of extraction only, this figure is reduced by a further 58.6 billion currency units to 529.4 billion currency units. If discoveries and natural growth are set against extraction, then the adjustment to NDP required to reach a figure for depletion-adjusted domestic product is 12.8 billion currency units, giving a total of 575.2 billion currency units.

10.226 The magnitude of the data entries in the SEEAland data set is thought to be realistic for a country well endowed with natural resources. On this basis, while adjustments for depletion are significant, they are not startlingly large, especially if discoveries are taken into account. Whereas NDP is approximately 85 per cent of GDP, depletion-adjusted domestic product is only about 2 per cent lower.

2. Defensive expenditure

Theoretical considerations

10.227 Identifying environmental protection expenditure within the SNA involves identifying some ancillary activity and identifying its output separately. This increases the value of both output and of intermediate consumption but leaves the values of GDP and NDP unaltered. Under the gross gross treatment suggested in section C, GDP is higher and NDP lower than in the conventional SNA. The difference between the two is increased by the total current expenditure on environmental protection. The same accounting identities are used to calculate the aggregates but these can be designated as being "defensive-adjusted".

10.228 Both treatments of defensive expenditure relate to income measures only, with no consequences for the state of environmental media explored.

Consistency of options

10.229 If the gross gross approach to environmental protection expenditure is adopted, it would be logical to extend this to other current repairs and maintenance also. This could provide a way of addressing similar issues such as the treatment of research and development expenditure and education expenditure, for example, though such considerations are beyond the scope of this handbook.

10.230 These options for defensive expenditure are entirely consistent with the options presented for the treatment of depletion and can be cumulated in any combination.

Practical considerations

10.231 Once the basic data needed for a satellite account showing environmental protection expenditure as described in chapter V are available, all the necessary information is available for incorporating explicit reference to environmental protection expenditure in the flow accounts of the complete system.

Institutional considerations

10.232 If there is no institutional objection to showing a satellite account for environmental protection expenditure, it is difficult to conceive that there would be any such objection to the identification of this form of defensive expenditure in satellite flow accounts.

Impact of adjustments on macroeconomic aggregates

10.233 The figures in Table 10.5 take account of environmental protection expenditure only. On this basis, they show an increase in GDP of just over 1 per cent and a decrease in NDP of about 1 per cent also. On this revised basis, NDP is 83 per cent of GDP compared (as before) with a ratio of the SNA aggregates of 85 per cent.

10.234 The environmental protection expenditure data are not as carefully estimated as those relating to natural resources but assuming they are broadly realistic, this might suggest that an adjustment for defensive expenditure could be of the same order of importance as an adjustment for depletion.

3. Degradation

Theoretical considerations

10.235 The theoretical considerations are different for each of the main approaches described.

Damage-based estimates

10.236 Damage-based estimates of degradation are broadly consistent with the concept of consumption of natural capital deriving from the asset-based approach to depletion. This allows damage to both produced and non-produced assets to be incorporated in the flow accounts in a parallel manner. The major extension is to treat damage to human health in a similar way as a decrease in welfare, rather than in wealth, and a matching decrease in income. The problem with this approach is that there is no absolute value to be placed on welfare, so that any resulting analysis should be conducted in terms of changes in welfare rather than in term of changes in absolute levels.

10.237 Because the damage is inflicted on units other than those causing the environmental degradation, this adjustment can be made only globally and not at the level of the individual sectors. On the other hand, adjustments for “environmental debt” can be made to show the carry-over effects from one period to another and also the effects of damage caused by cross-border flows of residuals.

10.238 Under this option, a new macro-aggregate, daNNI (damage-adjusted national income) is introduced which is lower than dpNDP by the amount of estimated damages.

Maintenance cost estimates

10.239 This approach is similar to the treatment of defensive expenditure. It makes adjustments to income without any corresponding consideration of the stock of environmental assets. It reflects a major conceptual weakness in that it assumes that a new set of prices or production changes can be introduced without consequences for the rest of the economy. At best, it can be seen as a snapshot or upper estimate of the value of degradation.

10.240 Under this option a new macro-aggregate, eaNDP (environmentally adjusted NDP) is introduced. Its relation to dpNDP and maintenance costs will depend on the exact nature of those costs, as explained in Box 10.9.

Greened economy estimates

10.241 These estimates are entirely consistent with the theoretical structure of the SNA but not with the existing economy measured by the current SNA estimates while the terms for macroeconomic aggregates are prefixed by "ge" under this option, this does not signify an accounting difference from their SNA equivalents.

Consistency of options

10.242 The three approaches are not consistent with one another, though the greened-economy estimates can be seen as growing out of the maintenance cost approach. Damage-based estimates focus on (negative) benefits and a stock approach where maintenance cost estimates focus on costs and income flows. There is no market mechanism to bring the costs and damages into line with one another except under the greened-economy alternative which is a modelling and not an accounting solution.

10.243 Any of the three approaches can be combined with the depletion and defensive expenditure options, but care must be taken that damages and costs are counted only once.

Practical considerations

10.244 All approaches present practical difficulties and their implementation may be resource-intensive. In all implementations, there is the question whether all degradation is to be valued (and, hopefully, avoided or restored) or whether the aim of the exercise is rather to explore the impact of improving environmental standards by only a given amount. When the techniques are to be used to make forward projections of (more) sustainable paths for the economy, questions arise over the degree of technical progress to be assumed and to what extent consumption and production patterns will change to be more environmentally benign. Not all of these changes may be driven by explicit concern over the environment. Fears about diseases linked to meat consumption may lead to greater consumption of less agriculturally intensive products; fear over terrorist activities may reduce air travel and thus the emissions from spent fuel.

10.245 The damage-based method assumes that the value of damage done is equal to the fall in value of environmental services provided. There is a question how much damage can be measured in this way. The techniques described assume that a causative relationship can be established between particular illness and specific pollutants and calibrated to an acceptable degree of accuracy.

10.246 An ideal data set for damage estimates would include emissions by industries in a hybrid accounting framework (by region), linked to physical distribution models for the pollutants, ambient concentrations in a geographical breakdown, and the population affected. Dose-response functions could then be applied to estimate the physical impacts and damages (respiratory diseases, damages to buildings etc.) which could then in turn be valued in monetary terms. In analytical applications, this linked data set would allow the monetary value of damage estimates to be linked to the initial causes (domestic and foreign). It would also allow the effects of alternative policy options, distributed geographically and by industry, on the damage estimates to be modelled. The hybrid accounting framework allows the avoidance cost calculations to be directly linked to the damage estimates, so that for each policy option a cost-benefit comparison can be performed.

10.247 The application of the maintenance cost approach can be highly resource-intensive. In principle, if a reduction in emissions can be brought about by one of several means, the relative costs of each should be estimated and the least expensive chosen. Not only is there a need to identify the appropriate solution to the given problem, but the question of the interaction between the cost level and the improvement in pollution prevention must be calibrated. This is an area where the macroeconomic figure is not necessarily a simple aggregate of numerous microstudies and further work is necessary to move from one level to another.

10.248 The greened-economy solution faces these problems, as well as the usual considerable problems of specifying how an economy will react to changes in prices and demand.

Institutional considerations

10.249 There are several reasons why a statistical office may decide not to pursue degradation-adjusted accounts. One reason is that, inasmuch as several institutions may be formally inhibited from undertaking modelling or projection work, the exercise will therefore fall outside their work programme. A second reason may involve reservations over the theoretical basis for the work. A third reason may revolve around the trade-off between resource cost and accuracy. Making such estimates is inevitably resource-intensive, in terms of both staff numbers and elapsed time, and the accuracy and timeliness of the results may not seem to justify this. Even with access to very considerable databases of relevant information, estimates of the value of degradation across the economy as a whole are likely to remain subject to significant margins of error for some time to come.

Impact of adjustments on macroeconomic aggregates

10.250 The SEEAland data set is not sufficiently elaborated to permit estimates of damage-adjusted aggregates. The research results available for a number of countries give a very wide range of proportionate adjustments. Not only will the range be wide, but the estimates will generally be held to be less robust than those for the other two adjustments.

4. Conclusion

10.251 The possibilities for incorporating adjustments for depletion and defensive expenditure into the flow accounts are much more promising for a statistical office at this time, although even here there may be reservations on theoretical or practical grounds about proceeding with the work. By contrast, it seems that work on degradation will stay mainly in the research field for some time.

10.252 Users should be advised that the establishment of robust and fully comprehensive environmentally adjusted accounts are unlikely in the very near future. Depending on individual circumstance, though, some partial estimates may be prepared, for example, covering depletion for mineral-rich economies and damage to human health in those countries with serious problems arising in large conurbations.

10.253 Many of the values estimated for the SEEA will ideally be site-specific, increasing the estimation burden. Again, concentrating on the largest problems first can help to reduce its effect on the accounts, and benefits-transfer methods offer a possible means to fill gaps where precise local estimates are unavailable.

10.254 Even so, economic aggregates arising from the SEEA will be necessarily less precise than those arising from the SNA. Collaboration with users as new versions of the accounts are developed is important with respect to allowing external review of the techniques adopted and the quality of the results and also to avoid raising unrealistic expectations among users.

10.255 One factor that should be noted by any policy maker concerned with a measure of income that preserves a given level of capital is that the first and most important adjustment to be taken into account is that transforming GDP into NDP by allowing for the depletion of the stock of produced assets. This adjustment ranges between 10 and 15 per cent for most countries and is potentially much greater than any adjustments made for either depletion or defensive expenditure.

Chapter XI. Applications and policy uses of the SEEA

A. Overview

1. Objectives

11.1. The present chapter attempts to give examples of the various applications and policy uses for the sort of tables and analyses described in this handbook. Its aim is not to be exhaustive or prescriptive but rather to introduce the reader to potential uses and to encourage him or her to be imaginative in the development of other applications.

11.2. The applications described may be classified into two broad categories. Those in the first category are closest to statistical tradition and concern the development of sets of indicators and descriptive statistics drawn from the different subject areas covered.

11.3. Applications belonging to the second category are concerned with how specific policy analyses can be based on the techniques covered in the Handbook. Policy analysis usually requires more specialized expertise in the techniques of economic analysis and modelling. The statistical offices in only a few countries extend their analyses into these areas. Consequently, in many countries, further use of the SEEA will require extensive cooperation between statistical offices and those agencies that have responsibility for and expertise in policy analysis and recommendations. The distinction between monitoring and policy analysis in this chapter is made to help statistical offices identify what they can reasonably do alone and what it may be preferable for them to undertake in collaboration with other agencies.

11.4. The common theme running through all applications is a concern with monitoring the pressures exerted by the economy on the environment and to explore how these might be abated. The order of subjects in the previous chapters is followed so that the questions of degradation, defensive expenditure and depletion are addressed in that order

11.5. Section B looks at the economic activities that lead to degradation of environmental media. It discusses the use of physical and hybrid flow accounts and draws on material from chapters III and IV.

11.6. Section C explores the existing responses to degradation through defensive expenditure and the development of economic instruments to tackle pollution at source. It draws on the material in chapters V and VI.

11.7. Section D discusses measures of national wealth and the changes in it due to depletion of the stock of natural resources. The techniques and analyses described here are particularly relevant for those who regard sustainability as a matter of maintaining wealth. It is based on the material described in chapters VII and VIII.

11.8. Section E examines how the application of prices to estimates of degradation in physical terms can be used to determine the cost-effectiveness of various strategies to combat degradation. The pricing techniques used are those described in chapter IX.

11.9. Section F shows how the techniques for valuing degradation described in Section E can be combined with valuation of depletion described in section D to make adjustments to the conventional macroeconomic aggregates. As described in chapter X, on which this section draws, some of these techniques go beyond statistical accounting into the realm of economic modelling.

11.10. Section G looks at sets of indicators for sustainable development such as those being developed by various international organizations and individual countries. The relevance of different parts of the SEEA for the lists of indicators suggested by the United Nations reflects of the application of the SEEA in this field.

2. Examples cited

11.11. The examples presented in this chapter constitute an addition to those presented in earlier chapters, in particular those in chapter VIII where extensive discussion is given to each of the five types of environmental assets based in large part on data for individual countries. In general, the earlier examples help to explain the technical derivation of the tables as well as to show their analytical usefulness, whereas the examples in this chapter concentrate on the reasons for undertaking various analyses rather than on the means of dong so.

B. Physical flow accounts and the causes of environmental degradation

11.12. The physical flow accounts described in chapter III can be used to establish detailed time trends of the generation of residuals and to determine the most important sources of pollution. By linking information from the physical accounts with that from hybrid accounts, a judgement can be made about the relative importance of the sector generating the residuals to the functioning of the economy so as to assess the significance of the level of residuals generated. The accounts provide information and indicators (for example, carrying capacity, total material requirements and "ecological footprints") that are useful for monitoring progress toward the dematerialization of the economy, or the decoupling of economic growth from material throughput. Thus, together, the two sorts of accounts help set priorities for policy based on the volume of residuals.

1. Indicators and descriptive statistics

11.13. Several examples of the application of physical and hybrid flow accounts are given in chapters III and IV. Of particular interest are the environmental-economic profiles developed by Statistics Netherlands in connection with its work on hybrid flow accounts (that is, the National Accounting Matrix including Environmental Accounts (NAMEA)).

Tracking the structural causes of residual generation

11.14. In order to design effective environmental policy, one must understand the reasons for the large differences in the amounts of residuals generated by different industries. The first step in this process is to distinguish between the role played by an industry's technology and the role played by the level of output.

11.15. The impact of technology can be measured by the residuals intensity of production, obtained by dividing total residuals from an industry by the output of that industry. These direct coefficients of residuals, material and energy intensity by industry can be used to rank industries in terms of their environmental impact. For industries with relatively large coefficients, even small changes in the levels of output can have a major impact on corresponding levels of residuals generation or material use. The coefficients can also be useful for benchmarking, to assess progress towards reducing residuals or material intensity of production within an industry over time, or to assess progress of one industry compared with another over time, or across countries.

11.16. It is important for policy makers to understand not just the phenomenon of direct generation of residuals associated with production but also the driving forces that underlie the production patterns. In the Netherlands example, a relatively small proportion of total residuals is generated by final consumers; most residuals result from industrial production. However, production takes place in order to supply other industries with the inputs they need and, ultimately, to supply final users with the products they want.

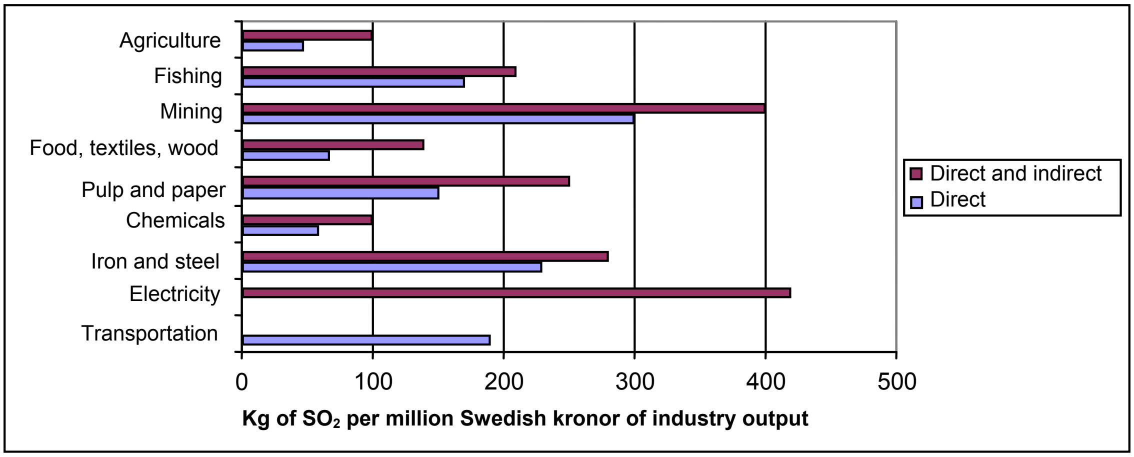
11.17. Each product purchased by final users requires an extensive web of "upstream" industrial production to supply it. Every stage of upstream production requires energy and material use and generates residuals; this is known as the indirect use of energy and materials and indirect residuals generation associated with deliveries to final users. Models based on hybrid input-output tables are used to measure the total impact of a given final use (that is, both the direct and indirect impact). In effect, this analysis redistributes emissions from industry to the driving force (final user) for which this production took place.

11.18. A comparison of the direct and total emissions of sulphur dioxide (SO_2) for each product delivered to final users in Sweden is provided in Figure 11.1, which shows, for example, that every purchase of 1 million kronor of agricultural output by final users results in the generation of nearly 50 kilograms (kg) of SO_2 by the agricultural industry. An additional 50 kg of SO_2 (for a total of 100 kg) is generated by the production of all the inputs required for production by the agricultural industry, for the incorporation of those inputs into agriculture and so on. Long experience with environmental input-output analysis has shown that the total impact is often much larger than the direct impact (Førsund, 1985; Miller and Blair, 1985; Pearson, 1989). Similar statistics have been constructed for a number of other countries such as the Netherlands (Keuning, Van Dalen and de Haan, 1999), Germany (Tjahjadi and others, 1999), Canada (Statistics Canada, 2001), Norway (Sørensen and Hass, 1998) and the United Kingdom (Vaze, 1999).

11.19. The ability to measure total residuals and direct plus indirect use of materials associated with given products, processes or consumption patterns allows the development of far more effective strategies for reducing the use and managing the disposal of materials than could be devised on the basis of direct use only. For example, Table 4.12 shows that public utilities, mainly electricity production, were responsible for 26 per cent of greenhouse gas emissions and 9 per cent of acidification emissions in the Netherlands. In attempting to reduce these emissions, policy makers can try not only to bring about technological change in the electric power industry to reduce emissions, but also identify who is purchasing electricity and try to change the behaviour of those users. It is often necessary to design policy for both groups – the direct source of residuals, and the users of products, whose demand drives the level of production and associated residuals.

11.20. The calculation of total emissions is particularly useful for understanding how the structure of an economy affects the levels of residual emissions and resource use. Final use can be disaggregated into its components, household consumption, government consumption, investment and exports, to determine how much of the total residuals generation in the economy occurs in order to meet the demands of each of these components. Because household consumption accounts for the greatest share of final demand, researchers have increasingly focused on the composition of household consumption as a critical component for sustainable development. Strategies for sustainable development have examined the impact of alternative household consumption patterns, particularly in the wealthy industrialized countries, where the need to identify "sustainable lifestyles" with corresponding consumption patterns has received a large amount of attention.

Figure 11.1. Direct and total emissions of sulphur dioxide per unit of industrial output delivered to final users, Sweden, 1991



Source: Hellsten, Ribàcke and Wickborn (1999).

Understanding changes over time through decomposition analysis

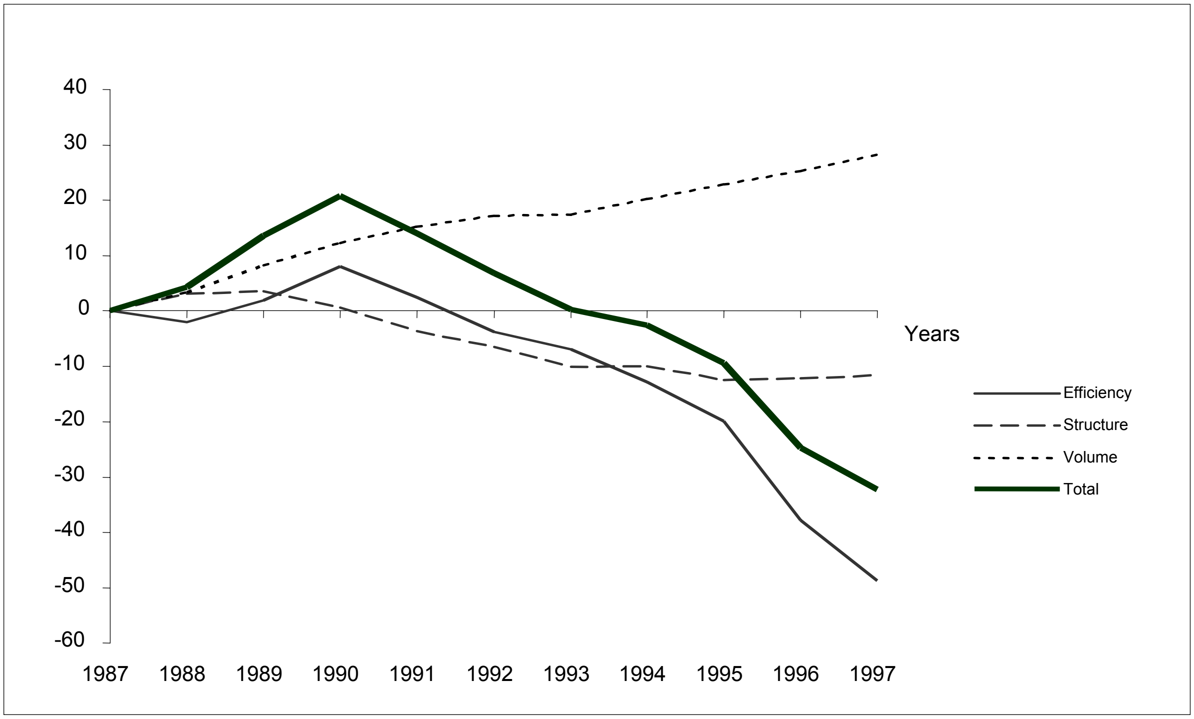
11.21. A formal and more thorough analysis of driving forces over time can be obtained by applying the technique of structural decomposition analysis to a hybrid input-output table. Over time, levels of emissions can change considerably and policy makers need to know how much of this might be the result of environmental policies. Policies affect the choice of technology as well as the level and composition of final demand and it is not immediately evident how much of the change in emissions is attributable to each factor. Are emissions falling mainly because of changes in production technology (and, if so, in which industries) or because of changes in the composition of final demand into a mix of goods and services with lower (total) emission requirements?

11.22. Structural decomposition analysis is a technique developed to distinguish the different sources of change in the economy over time by decomposing differences in the direct plus indirect requirements matrices derived from the input-output tables. A recent application of decomposition analysis for residuals using the NAMEA for the Netherlands was carried out by de Haan (2001) for the period 1987-1998. The study addressed changes in the levels of greenhouse gas emissions, acidification emissions and solid waste. It distinguished three major factors affecting residuals: economic growth (volume of production), changing composition of final demand, and changes in technology. A description of the results for greenhouse gas emissions is given in chapter IV comparing the figures for the Netherlands and the United Kingdom. For greenhouse gas emissions, economic growth outweighed the impact of improved efficiency and structural change, resulting in rising emissions over time. For acid emissions, economic growth tended to increase but this trend was outweighed by emission reductions brought about through technological change. The change in the composition of final demand had relatively little impact and the net effect was a decline in acidification emissions over the period.

11.23. Solid waste generation increased from 1987 to 1990 but declined thereafter owing to substantial improvements in technology and, to a lesser degree, changes in the composition of final demand. With no gains from efficiency due to technological developments or changing structure, it would be expected that solid waste generation would have grown in line with the growth in the volume of production over the period (28 per cent). In the case of the Netherlands, reductions due to eco-efficiency gains (48 per cent) and effects of structural changes (12 per cent) resulted in an overall decrease of 32 per cent. These results are shown in Figure 11.2.

11.24. While only the aggregate figures for each of the three major factors are reported, each of the factors, in turn, can be disaggregated to the level of industrial classification used for the analysis. In some countries, this can include 500 industries or more, allowing an extremely detailed and complete analysis of the causes of changes over time.

Figure 11.2. Decomposition of changes in production-related solid waste generation, Netherlands, 1987-1998



Source: de Haan (2001).

11.25. In the conclusion to the study, de Haan stressed the importance of extending this analysis to the entire EU region in order to better account for intra-EU trade. A limitation in respect of this analysis is connected with having to estimate the residual content of imported products. Without environmental accounts for a country's major trading partners, one cannot accurately estimate the extent to which an environmental problem has improved (or worsened) simply because products are no longer produced domestically but are imported instead. Environmental management would certainly benefit from a consistent set of multi-country accounts that could be used for regional analysis.

11.26. The examples discussed above concern residuals. However, this kind of analysis is equally important for material flows as well. There is an extensive literature on this kind of analysis for energy use. The construction and analysis of flow accounts for water have also received attention, especially in countries of water scarcity. Water accounts are a priority component of the environmental accounts in France, Spain, the Republic of Moldova, Chile, Namibia, Botswana and South Africa.

2. Policy analysis and strategic planning

11.27. So far, the discussion has focused on analysis of the interaction between the existing environment and the economy, but policy makers also need to look to the future and design effective instruments for environmental policy. Strategic analysis is conducted to explore the various possible alternatives in order to design a more desirable future. Countries typically identify the broad environmental objectives they wish to achieve in the future, such as more sustainable development and more sustainable lifestyles. Pursuant to these objectives, specific problems, such as air quality, are identified and more detailed strategies to address these problems are examined in a modelling framework. This analysis is often based on long-term models for exploring alternative scenarios about paths of economic development.

11.28. Strategic planning addresses a relatively long time-horizon (10-25 years or more) and fundamental changes in the structure of the economy that might be necessary to achieve society's environmental objectives. Examples of strategic planning include the Netherlands National Environmental Policy Plan, a long-term project for sustainable development and routine strategic macroeconomic planning models (for example, the Multisector Growth Model of Norway's Ministry of Finance which has integrated environmental components for energy and residuals). Strategic planning often emphasizes dynamic modelling instead of the static analysis commonly used for policy analysis. Dynamic analysis is important because it informs policy makers about the transition path (that is, the process of adjustment to a different economy).

11.29. Once the possible overall strategies are determined, policy analysis involves choosing the best alternatives and preparing to implement them. This analysis considers different instruments that policy makers might choose (usually a small range of actions over a relatively short period of time, such as different values for a carbon tax) and provides policy makers with the most likely outcome of these actions Policy models can be used to examine the economic implications of various environmental policy instruments, such as taxes, tradable permits, and emission standards, as well as macroeconomic policies, such as trade policy, and their impact on the environment.

Examples of policy analysis

11.30. In parts of Australia, the United States of America and Southern Africa, water scarcity is as critical an issue as water quality. Flow accounts for water have been used in a computable general equilibrium (CGE) model to address new water pricing policies in South Africa (Hassan, 1998). In the past, water prices were very low with little regard for cost or scarcity, especially for agricultural use. The proposed new pricing policy includes full-cost recovery tariffs with a guaranteed "lifeline" amount of water supplied to all households, as well as innovative pricing policies such as a user charge for the reduction of rainfall runoff caused by commercial plantations of exotic forest species.

11.31. A broad range of policy studies was undertaken in the Philippines, including an assessment of the environmental implications of rice self-sufficiency (land, water and residuals), a study of trade and environment linkages, and a study of the environmental implications of alternative land-use patterns (Philippine Environmental and Natural Resource Accounting Project (ENRAP), 1999).

11.32. Another application of the physical flow accounts is life-cycle analysis (LCA). Traditionally, LCA is a bottom-up process analysis based on linking the specific processes in a supply chain in order to trace the environmental impacts from "cradle to grave" of specific products or production processes. The advantage of this extremely detailed approach is its capacity to represent environmental impacts precisely. However, a major limitation of process-based LCA is the likelihood that important parts of the product systems are left out of the analysis, simply because it is difficult to follow the entire supply chain in such detail.

11.33. In some instances, practitioners have attempted to address this problem through the use of so-called hybrid life-cycle analysis or environmental input-output life-cycle analysis, in which the detailed partial LCA is combined with economy-wide input-output analysis. Physical flow accounts for inputs of natural resources and outputs of residuals are combined with input-output analysis as a supplement to traditional process-oriented LCA (see the journal *Industrial Ecology* for regular articles on theoretical and empirical aspects of this topic). While input-output data, based on averages of intermediate consumption, natural resource use and residuals for industries, may be less accurate than process-level analysis, the input-output analysis ensures that all the indirect effects are taken into account. In hybrid analysis, process analysis is often used for the first few rounds, followed by input-output analysis for those remaining.

11.34. This method has been used to calculate the total CO_2 impact from Danish household consumption of 72 different commodities (Munksgaard, 2001). It has also been applied to examine the environmental implications of introducing fuel cell electric vehicles in the United States of America (Gloria, 2001). The combination of traditional LCA with input-output has been used in the United Kingdom of Great Britain Northern Ireland to explore aspects of climate change policies, as reflected, inter alia, in the development of a model for carbon emissions trading (Shipworth, 2000) and an analysis to identify the industries that would gain and lose the most from carbon taxes (Ecotec, 1999).

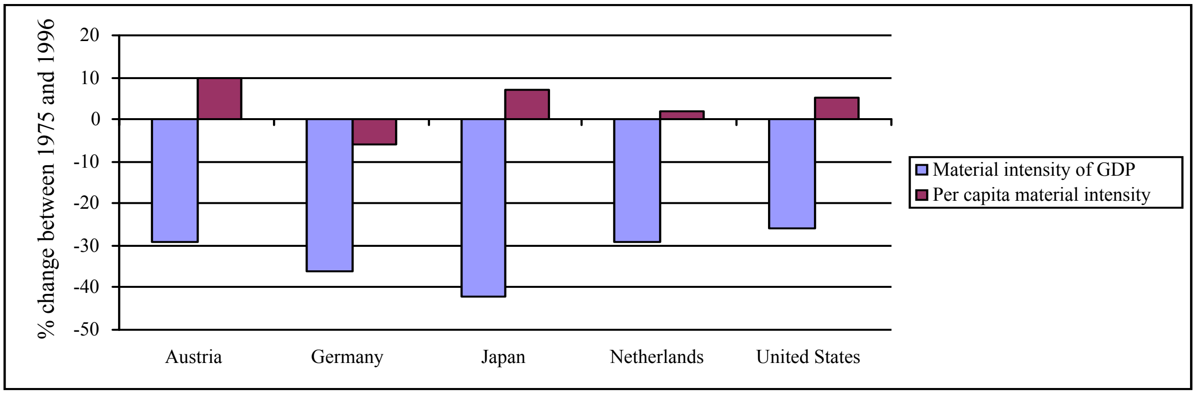
Material flow accounts

11.35. Material flow accounts (MFAs), as explained in chapter III, attempt the comprehensive tracking of all material use into, through and out of the economy. In the words of two of their creators, "instead of regarding physical materials as essentially incidental to the system we now choose to regard the economic system itself as a material flow process" (Saxton and Ayres, 1976, p.192). MFAs were developed to address sustainability based on the ecological concept of dematerialization, or the de-linking of economic growth from material use (Spangenberg and others, 1999). MFAs are similar to the SEEA physical flow accounts in that they record the use of materials and the generation of residuals, although MFAs are not always fully disaggregated by industry. The SEEA physical flow accounts can improve upon MFAs by providing information about much of the material use disaggregated by industry. However, MFAs also include the "hidden flows," which consist of materials excavated or disturbed along with the desired material, but do not themselves enter the economy. Examples of hidden flows include mine tailings or soil excavated during construction. MFAs also distinguish between dissipative use flows and flows that are embodied in products. Dissipative flows are materials that are shed from products during the normal course of use, such as fertilizer, or rubber worn away from motor vehicle tyres.

11.36. MFAs have been constructed by a number of countries. An ambitious project by the World Resources Institute compiled roughly comparable MFAs for five industrialized countries: Austria, Germany, Japan, the Netherlands and the United States (Matthews and others, 2000). An important sustainability goal for environmentalists has been the decoupling of economic growth from material use, a concept popularized by the "Factor Four" movement which aims to halve total material requirements (TMR) while doubling wealth and welfare (von Weizsäcker, Lovins and Lovins, 1997). The World Resources Institute study showed significant decoupling in the countries studied: since 1975, the material intensity of GDP in all five countries had declined by 20-40 per cent. This is shown in Figure 11.3, not in terms of TMR but as domestic processed output relative to GDP. This decoupling was the result of efforts to reduce the volume of solid waste and the shift away from energy- and material-intensive industries towards knowledge-based and service industries. However, per capita material intensity had not declined in most countries over this time period; only Germany showed a decline (6 per cent). The authors attributed the general increase to economic growth and consumer choices that favoured energy- and material-intensive lifestyles. The figures for Germany were strongly influenced by the effects of reunification and the subsequent closure of some heavy industries in the eastern Länder.

11.37. The MFAs do not differentiate materials by their environmental impact; highly toxic materials are simply added to materials like timber or gravel that may be much less environmentally damaging. Consequently, the sustainability goals set under this framework, such as Factor Four, appear rather vague for use as guides to policy on their own and require more detail to be interpreted correctly. Indicators created for certain categories of materials whose environmental impacts are more similar, such as the NAMEA theme indicators, may be more useful. Nevertheless, the relation between these indicators and total output or trends over time can provide insight into whether countries are working towards overall goals of reducing their impact on the environment.

Figure 11.3. Percentage change in material use in five industrialized countries, 1975-1996



Source: Matthews and others (2000), p. 20.

Note: Material intensity calculated as domestic processed output/GDP.

Per capita material intensity calculated as domestic processed output/population.

Domestic Processed Output = domestic extraction + imports – net additions to stock – exports.

11.38. A somewhat similar exercise has been carried out by Eurostat for the 15 EU member countries. Here the indicator of reference was material consumption. Unlike TMR, this does not include hidden flows (that is, material that is moved by economic activity but not absorbed by it, such as mining overburden and water for hydroelectric use). Material consumption relates to materials extracted domestically plus those imported less those exported. It is equal to the additions to material stock in buildings, infrastructure, machinery etc., plus materials returned to the environment whether as emissions to air and water, waste sent to landfill, or materials dissipated during use.

11.39. Material consumption is a useful indicator by which to track the changes in production and consumption and the level of production and consumption material use over time. In economic terms, the indicator shows the dependence on physical resources and the efficiency with which materials are used. In environmental terms, it is a background indicator for the overall environmental pressures generated by the production and consumption of goods associated with material extraction and transformation, waste, land use and so on. Preliminary estimates for EU countries in 1990 and 1997 are shown in Table 11.1.

11.40. The applications of the flow accounts discussed so far in this section have been at the national level. However, a country trying to design a more sustainable economy can face two problems. First, it may find that, although domestic emissions are low, it still suffers from environmental degradation because of emissions from other countries that are transported by air or water. Second, as small open economies typically import many products, the pollutants associated with the imported products might be quite high. Such an economy may appear "clean" on the basis of its domestic emissions, but its imports may be responsible for generating emissions elsewhere.

11.41. Certain environmental issues are regional or global in nature and require international management. For example, acidification and eutrophication are regional problems in most parts of the world; climate change and ozone depletion are global problems. Construction of national-level environmental accounts may not be sufficient for effective policy design if much of a country's residuals are imported. In this case, the accounts need to include the international transfers of residuals, as discussed in chapter III.

Table 11.1. Material consumption in EU countries (preliminary estimates)

Country	Millions of tons			Tons per capita		
	1990	1997	Percentage change	1990	1997	Percentage change
Austria	143	158	10	19	19.5	3
Belgium/Luxembourg	184	193	5	18	18.3	2
Denmark	119	145	22	23.2	27.6	19
Finland	197	182	-8	41.3	35.3	-15
France	1 101	1 062	-4	20.4	18.2	-11
Germany	1 744	1 696	-3	22.3	20.7	-7
Greece	133	191	44	13.8	18.1	31
Ireland	136	147	8	40	40.3	1
Italy	720	791	10	12.8	13.8	8
Netherlands	229	240	5	16.2	15.4	-5
Portugal	117	124	6	12	12.6	5
Spain	645	868	35	17.2	21.9	27
Sweden	248	242	-2	29.8	27.3	-8
United Kingdom	832	925	11	14.7	15.7	7
EU total	6 545	7 025	7	18.4	18.8	2
Biomass	2 145	2 322	8	6	6.2	3
Fossil fuels	1 473	1 419	-4	4.1	3.8	-7
Minerals	2 927	3 284	12	8.2	8.8	7

Source: Eurostat (2001c).

Extension from national to regional analysis

11.42. International trade has led to a dissociation of consumption in one country of products that cause environmental degradation from production in another where the degradation occurs. For example, Australia appears to be a highly energy-intensive country. However, much of this energy is embodied in products that it exports to other countries. On the basis of their direct energy use, the countries to which Australia exports may appear to have achieved low energy intensities for their economies.

11.43. Attempts have been made (using the so-called ecological footprint, for example) to take imports into account when assessing a country's total environmental impact. Ideally, for this purpose, information on the technologies in use in the countries of origin of the imports should be used to accurately determine the environmental content of imports. Often, however, these data are not available and more approximate methods must be used, sometimes assuming that the imports are made with the same technology as that adopted in the importing country and therefore have the same residuals and energy coefficients per unit of output. The construction of flow accounts by many countries would make it possible to substitute more appropriate information for this highly unlikely assumption. This would greatly improve the estimates of the true environmental burden of a country's consumption patterns.

11.44. Sweden undertook a pilot study to compare the emissions embodied in its imports encompassing three alternative methods. The first used Swedish industry-level emission coefficients for imports; the second, national average emission intensity for all imports from each country based on emissions data for all EU countries plus other major trading partners (United States, Japan, Norway and Switzerland); and the third, industry-specific emissions coefficients for each country, derived from their environmental accounts. Data for the first two methods were obtained for 1995; however, data for the third method were available only for 1993, hence its results are not strictly comparable with results from the other two methods. The results are shown in Table 11.2.

11.45. The results for CO_2, SO_2 and NO_X emissions embodied in imports reflected an extreme sensitivity to the method used. The lowest estimate of CO_2 and SO_2 emissions occurred when Swedish emission coefficients were used; estimates of emissions using the other two methods were at least 50 per cent higher. The reverse occurred for NO_X: Swedish emission coefficients gave the highest level of NO_X emissions, although the level was not much higher than the levels found using the other two methods. The results reveal significant differences among countries in emission intensities. While there are a number of methodological and data improvements needed, this pilot study indicates the importance of obtaining environmental accounts for all major trading partners in order to correctly evaluate the emissions embodied in imports.

Table 11.2. Emissions embodied in Swedish imports under alternative assumptions about emission intensities of imports, 1995

	CO_2	SO_2	NO_X
Method 1: Swedish emission coefficients	20 800	43	128
Method 2: National average emission coefficients from exporting country	32 900	121	119
Method 3: Industry-specific emission coefficients from exporting country	36 300	128	109

Source: Statistics Sweden (2000).

Note: Method 3 used data from 1993 hence the results are not directly comparable with those obtained using the other two methods.

C. Combating environmental degradation

11.46. The present section describes the use of the SNA to identify the costs currently incurred to prevent environmental degradation and to explore means to discourage continuing residuals in the future. The first use concerns the accounts for environmental protection expenditure and resource management described in chapter V and the second entails the deployment of economic instruments such as eco-taxes and the issuing of licences described in chapter VI.

11.47. As described in chapter V, the SEEA seeks to highlight information about defensive expenditures, making it more explicit and so more useful for policy analysis. This part of the SEEA is similar to other satellite accounts, such as transportation or tourism accounts, which do not necessarily add new information, but reorganize existing information. It provides the basis for exploring the consequences of the introduction of new levels of environmental protection expenditure whether they are introduced voluntarily or in response to government legislation.

11.48. Indicators of environmental protection attempt to identify some of the efforts undertaken by society to prevent or to reduce pressures on the environment. The interpretation of these indicators can be ambiguous because technological solutions to residuals generation sometimes result in joint reduction of production costs as well as residuals generation and this dual effect is not captured in the environmental protection expenditure accounts. Similarly, increases in environmental protection expenditure may not keep pace with increasing levels of residuals generation. Thus increases or decreases in environmental protection expenditure cannot be interpreted unambiguously as showing whether the economy is becoming more or less sustainable.

11.49. In addition to monitoring environmental protection expenditure, the accounts show the transactions related to the imposition of environmentally related taxes, the granting of subsidies that affect the use made of the environment, and the ways in which environmental resources cease to be free by virtue of the requirement that users pay for their use either on a continuing basis or through the issue of a licence authorizing their use. Economic modelling can be used in connection with these accounting entries to examine how changes in these economic instruments would affect use of environmental resources in future.

11.50. The first part of this section addresses the construction of descriptive statistics and indicators from these accounts for use in monitoring environmental protection and resource management activities. The second section discusses the use of the accounts for analysis and policy modelling.

1. Indicators and descriptive statistics

11.51. Environmental regulation has been highly controversial in most countries and these accounts may help to address some of the important questions surrounding regulation, for example, whether the money spent on residuals abatement has been effective in reducing residuals and whether environmental regulation has affected productivity and international competitiveness. To better understand the impact of environmental protection and resource management expenditures on the economy, it is useful, in the first instance, simply to track some of these expenditures over time. A set of descriptive statistics provides policy makers with information, for example, on:

- The magnitude of environment protection expenditures and economic instruments in the economy (overview).

- How environmental protection expenditure is related to specific production activities and environmental concerns.

- Whether the costs are incurred by the public or private sector, by industries (and, if so, which) or by households.

- The extent to which environmental taxes match the environmental burden imposed by each industry.

- How important the environment protection industry is to the economy in terms of, for example, employment.

- What the possibilities are for growth through specialization in environmental protection and international trade.

11.52. Spending on environmental protection is a burden that needs to be monitored. Table 11.3 shows expenditures for environmental protection (called pollution abatement and control) in the United States in 1972, 1980, 1994. Pollution abatement expenditures are by far the most important, accounting for over 90 per cent of all spending, with the remaining spent on monitoring and regulation and on research and development. All regulation and monitoring and most research and development are undertaken by government.

11.53. In 1972, most of the spending was for water pollution (43 per cent), followed by air pollution (39 per cent) and solid waste (19 per cent). The picture in 1980 was not significantly different, but by 1994 priorities had changed and spending was more evenly distributed across environmental domains. Spending on water pollution still dominated (35 per cent), but spending on solid waste was nearly the same (34 per cent) and spending on air pollution (31 per cent) was close behind. In 1994, businesses split their expenditures almost equally among the three categories, while government spent almost half on water and almost half on solid waste.

Table 11.3. Pollution abatement and control (PAC) expenditures in the United States, 1972, 1980 and 1994 (Percentage)

	Proportion of total PAC	Proportion of category		
		Air	Water	Solid waste
1972				
Pollution abatement and control	100.0	38.2	42.8	18.9
Pollution abatement	92.9	36.4	43.7	19.9
Personal consumption	8.1	100.0	0.0	0.0
Business	64.2	38.8	43.2	18.0
Government	20.5	3.5	62.9	33.6
Regulation, monitoring, R and D	7.2	67.3	28.6	4.1
1980				
Pollution abatement and control	100.0	43.1	39.8	17.0
Pollution abatement	94.1	42.7	40.5	16.9
Personal consumption	13.1	100.0	0.0	0.0
Business	59.1	44.3	37.6	18.1
Government	21.9	3.4	73.1	23.5
Regulation, monitoring, R and D	5.9	52.3	27.3	20.4
1994				
Pollution abatement and control	100.0	30.9	34.8	34.3
Pollution abatement	96.6	30.4	35.0	34.6
Personal consumption	8.0	100.0	0.0	0.0
Business	62.9	31.9	34.7	33.4
Government	25.6	4.6	46.7	48.7
Regulation, monitoring, R and D	3.4	49.0	28.6	22.5

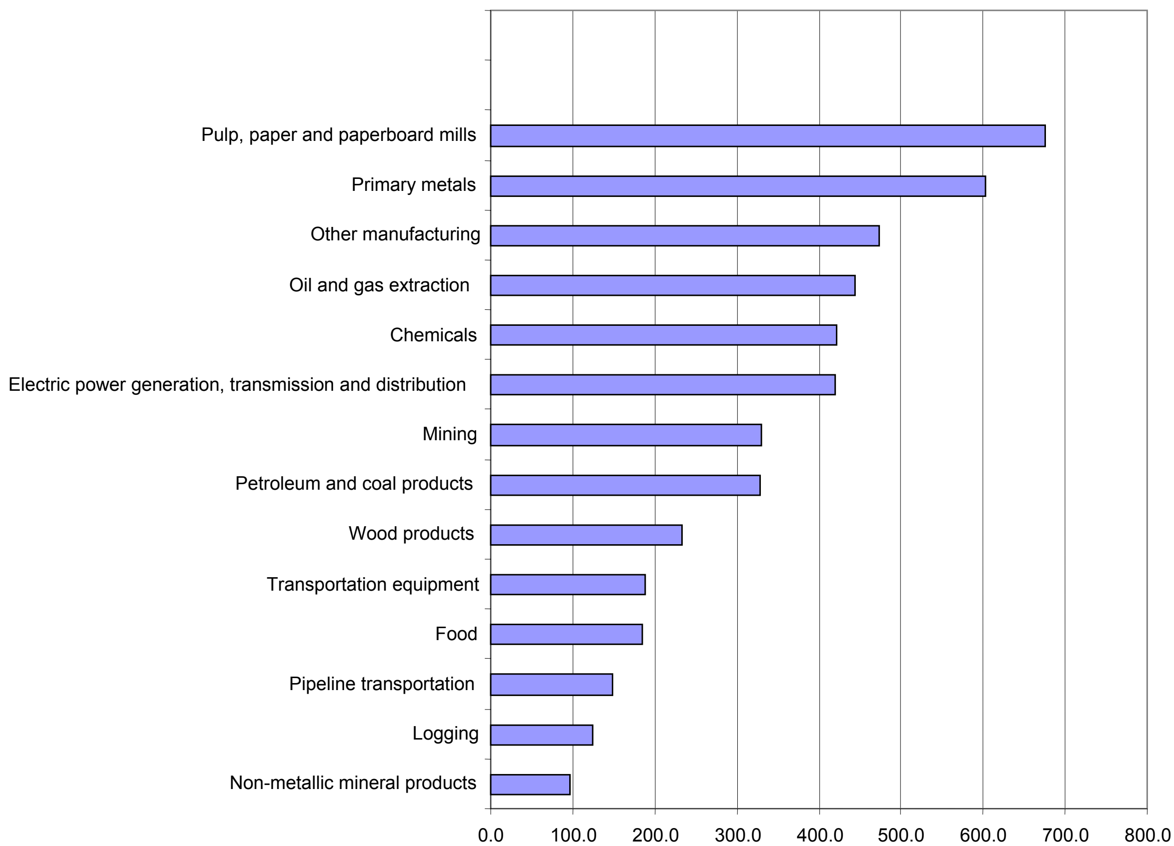
Source: Vogan (1996).

11.54. As a proportion of GDP, United States environmental protection expenditures have remained constant at between 1.7 and 1.8 per cent. About two thirds of the spending for pollution abatement and control is undertaken by the private sector. The share of spending by households, mostly for motor vehicle pollution abatement devices, has remained constant at about 8 per cent of the total. However, there was a rise in the share of spending by government between 1972 and 1994 from 21 to 26 per cent, matched by a decline in private sector expenditures.

11.55. A more detailed breakdown of expenditures by industry can be used to identify which economic activities bear the greatest burden of environmental regulation. Figure 11.4 shows spending in Canada in 1998 by industry (Statistics Canada, 2000). Five industries accounted for 55 per cent of all environmental protection expenditure: electric power generation, chemicals, oil and gas extractions, primary metals and pulp and paper. The Canadian data also provide a breakdown by province. The industrial and geographical disaggregation allows policy makers to identify the industries and communities that would be most affected by new environmental policies and to design measures to assist them if necessary.

Figure 11.4. Environmental protection expenditures, by industry, Canada, 1998

Millions of Canadian dollars



Source: Statistics Canada (2000).

11.56. The NAMEA constructed by Statistics Netherlands introduces the idea of environmental domains. The domains distinguished are water, air, soil, waste, noise and landscape. The main purpose of this breakdown is to provide a closer connection between environmental expenditures and the physical accounts in the NAMEA. The recent revision to the Netherlands national accounts has been used to improve the data on environmental expenditure in its NAMEA. First of all, two new surveys on "Recycling" (NACE code 37) and on "Sewage and refuse disposal, sanitation and similar activities" (NACE code 90) were used and integrated in the NAMEA. Further, the ancillary environmental expenditures were updated and a more detailed breakdown among the environmental domains to which the expenditure is directed was established.

11.57. As a measure of economic burden, environmental protection expenditure can be calculated as a percentage of industry costs, as a percentage of household expenditures and as a percentage of government spending. These expenditures can also be disaggregated between current and capital expenditures. This more detailed picture of environmental protection expenditure may allow further analysis, such as investigation of the impact of environmental regulation on competitiveness and productivity. Table 11.4 provides a more detailed list of indicators of potential use to policy makers.

11.58. There has been some criticism to the effect that the environmental protection expenditure accounts focus too much on the expenditure side which emphasizes the extra costs imposed by environmental regulation. Possibilities for revenue and cost savings through implementation of process-integrated environmental measures have not received the same degree of attention. A Swedish environmental protection expenditure survey included questions about cost savings and found that a large share of companies were engaged in cost-reducing or revenue-enhancing measures that had not been covered by the standard environmental protection expenditure survey instrument (Johansson, 2000). As companies adopt process-integrated pollution prevention instead of pollution abatement approaches, the conventional environmental protection expenditure accounts become less useful in analysing the economic impact of environmental regulation or the likely response to changes in regulation.

Table 11.4. Examples of policy issues and related indicators of environmental protection

Policy issue	Variables/indicators	Users
Net cost of environmental goods and services (net of any savings from environmental activity); cost/benefit analysis of environmental regulations and voluntary initiatives	Investment spending and current expenditures on environmental protection; cost savings, energy savings from environmental technologies or products	Industry, industry associations, environment departments and other government bodies, universities
Contribution of environment industry to economic growth, production and employment; potential for aid to industry	Relative yearly growth in turnover (revenues), value added, employment, type of jobs etc.	Governments (environment, industry and finance departments in particular); industry associations (including environment industry associations); universities; marketing consultants
Contribution of environmental goods and services industry to international trade	Exports, imports (absolute amounts and as a percentage of total exports/imports), international direct investment, licensing agreements	Governments and industry associations, exporters and importers
Regional and structural differences in characteristics and importance of environment industry	Turnover, value added, employment, etc. by region, by industry structure, etc.	Regional governments, industry associations, national and regional
Environmental protection and R&D and innovation potential	Environmental R&D as a share of total R&D; new patents for environmental technology	Governments, industry, universities
Economic efficiency	Price per unit of environmental protection services (for example, dollars per ton of treated waste)	Governments, industry
Adequacy of environmental products and technologies with respect to environmental protection goals (environmental efficiency)	Linkages of environment industry activities and characteristics to environmental quality indicators	Governments, industry, universities
Contribution of environment industry to sustainable development	Preventive activities (for example, cleaner technologies and products) as a share of total environment industry output	Governments, industry, universities
Transfer of environmental technologies	Share of imports and exports of environmental capital expenditures	Governments, industry, intergovernmental organizations

Source: Modified from Drouet (1997).

11.59. While environmental protection expenditures have imposed substantial costs, they have also created opportunities. Entirely new industries have arisen to fill the need for environmental services. The second part of the environmental protection expenditure accounts provides a clear description of this industry, and its contribution to GDP, to employment and to exports. For some countries, the environmental services industry has become an important exporter, while other countries are large importers of these services. For example, in France, the environmental services industry accounted for 2.3 per cent of GDP and 1.4 per cent of employment in 1997. More than half the employment was in solid waste and wastewater management (Desaulty and Templé, 1999).

Environmental taxes

11.60. Environmental taxes and subsidies are important policy instruments for implementing the "polluter pays principle" which has been adopted by many countries. The tax component of the environmental protection expenditure accounts can be very useful in assessing whether the tax regime is promoting sustainable development. Eurostat has compiled a time series of environmental taxes for its 15 member countries (Steurer, Jaegers and Todsen, 2000). The share of environmental taxes in total tax revenue is small but increasingly significant, having grown from 6.7 per cent in 1980 to 7.6 per cent in 1997. Among the different environmental taxes (on energy, transport, pollution and resources), energy taxes dominate and currently account for about three quarters of environmental taxes.

11.61. To determine whether environmental taxes have been successful in implementing the polluter pays principle, further analysis of the environmental protection expenditure tax accounts is needed. The Swedish Environmental Protection Agency undertook such a study, the results of which are shown in Table 11.5. Environmental taxes, which rose from 49.7 billion Swedish kronor in 1993 to 61.6 billion Swedish kronor in 1998, are dominated by energy taxes, which include carbon taxes.

Table 11.5. Environmental taxes, Sweden, 1993-1998

(Millions of Swedish kronor in current prices)

Taxes on	1993	1994	1995	1996	1997	1998
Energy	39 017	42 043	44 161	49 733	49 352	52 652
Pollution	582	566	682	753	551	508
Transport	8 119	5 852	5 798	6 721	6 451	6 336
Resources	_	_	_	70	131	142
Total	49 711	50 455	52 636	59 273	58 482	61 636

Source: Sjölin and Wadeskog (2000).

Note: A dash (-) indicates that the amount is nil.

11.62. Linked with the physical accounts for energy, the tax accounts show the extent to which the polluter pays principle is being followed. CO_2 emissions and carbon taxes paid for five groups of industries and private consumption as share of their respective totals in Sweden in 1997 are shown in Figure 11.5.

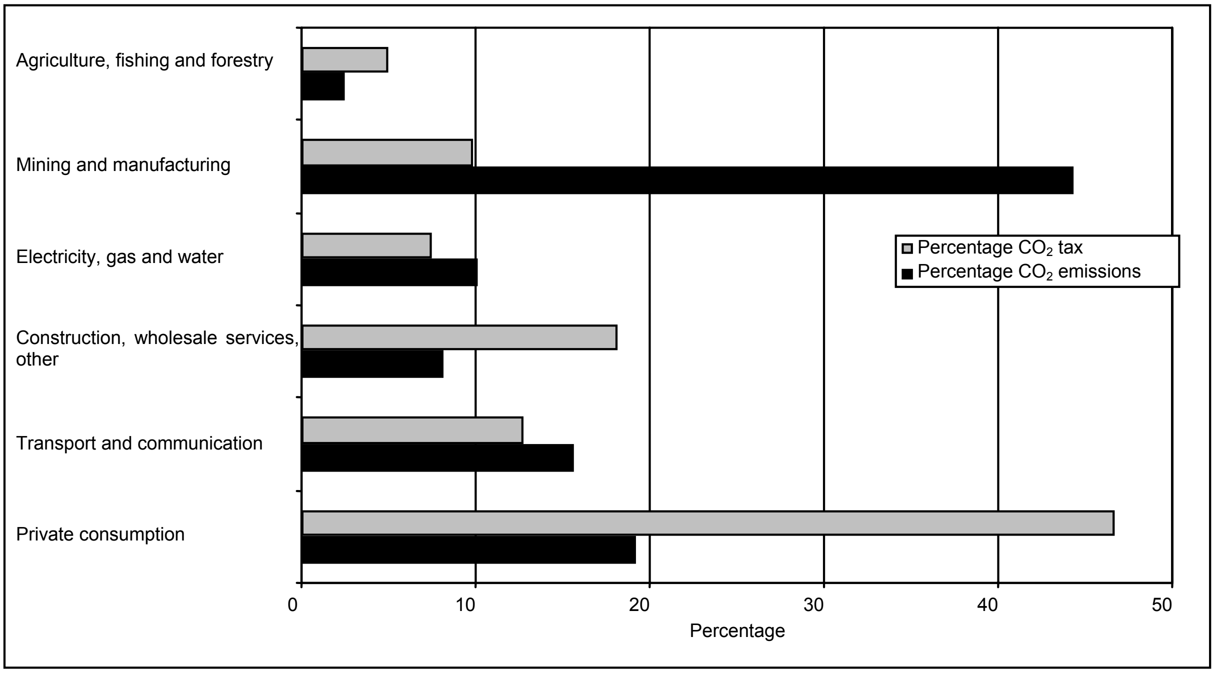
2. Policy analysis and strategic planning

11.63. There are now quite a few examples of the use of environmental protection expenditure for policy analysis and strategic planning, in particular for the design of economic instruments when the accounts are linked to economic models. The applications cover four broad topics: the economic impact of environmental regulation, the economic impact of environmental taxes, the assessment of the costs of regulation relative to their benefits in terms of reduced levels of pollution, and the impacts of recycling and reuse.

11.64. One way of using environmental protection expenditure accounts is to model the effects of assumed changes in environmental protection measures in order to estimate the way in which such changes will affect, both directly and indirectly, environmental pressure, economic activity, growth and employment in the future. A particular use of such models may be in constructing the abatement cost curves whose use was discussed in chapter IX.

11.65. The economic impact of taxes on resources and residuals is a major policy issue. Several countries have looked at the structure of taxation with particular reference to taxation of labour relative to the taxation of natural resources, environmental goods and services, emissions and discharges, and so on. Policy makers need to know not only how high to set taxes to achieve a certain reduction in residuals, but also what the economic impact of these taxes would be compared with that of an existing tax structure, a subject discussed earlier in this chapter. Impacts include domestic restructuring of the economy and its effect on specific industries and communities, as well as effects on international competitiveness.

Figure 11.5. CO_2 emissions and Carbon taxes, by industry group and private consumption Sweden, 1997



Source: Sjölin and Wadeskog (2000).

11.66. Norway has used the flow accounts to assess a policy that many countries are considering, (the so-called double dividend) that is, changing the structure of taxes to increase taxes on emissions and/or resource use while simultaneously reducing other taxes by an equal amount in order to remain fiscally neutral (Statistics Norway, 1998). Norway used its multisector general equilibrium model to look specifically at increasing the carbon tax to Norwegian kronor 700 per ton of CO_2 and decreasing its payroll tax. Policy makers in Norway wanted to know what effects this tax reform would have on economic welfare.

11.67. Using a multisector general equilibrium model of the economy, Norway initially found that employment and economic welfare would increase while carbon emissions declined. However, closer analysis of the results indicated that the tax reform would result in significant structural change in the economy. Certain energy-intensive industries in the metal, chemical and oil refining sectors would be particularly hard hit by the tax and would reduce output and employment considerably. Furthermore, these industries were disproportionately located in small towns where an industry might be the only major employer. It is reasonable to assume that, at least in the short term, people would be reluctant to move to new towns in search of new jobs. By including this element of labour immobility, the model showed that, although emissions still declined, the economic improvement disappeared and economic welfare actually declined slightly.

11.68. In considering environmental taxes, another issue policy makers must consider is the impact such taxes might have on the international competitiveness of their domestic industries. This is an especially important issue for highly open economies like that of the Netherlands. A study addressing this issue for the Netherlands was undertaken using the flow accounts for energy as well as for carbon emissions, other greenhouse gas emissions, acidification and eutrophication emissions (Komen and Peerlings, 1999). The study quantified the relative sensitivity of the different industries to changes in environmental taxes.

11.69. A major concern of policy makers has been the evaluation of the costs of environmental regulation relative to the benefits in terms of reductions in residuals. With integration of environmental protection accounts and the physical flow accounts, it may be possible to trace the relationship between expenditures (or taxes) and changing levels of resource use, residuals emissions and solid waste. For example, linking accounts for actual emissions to water (or for water quality) with the accounts for wastewater management expenditures (or effluent taxes) provides an indication of the effectiveness of spending in reducing residuals. However, there are difficulties inherent in interpreting this relationship because of the time differential between the expenditure and the environmental benefit resulting from that expenditure. Also, interpretation may not be unambiguous unless the analysis is carried out at the firm level, with supplemental information about the residuals control measures not included in the environmental protection expenditure.

11.70. As mentioned earlier, this approach does not take into account the increasing potential for pollution prevention through process redesign, which may even reduce both production costs and emissions simultaneously. In another example, Swedish researchers were able to show policy makers that policies to reduce carbon emissions may generate additional unintended (or ancillary) benefits which should be taken into account when considering the advantages and disadvantages of different environmental policy reforms (Nilsson and Huhtala, 2000). The study analysed the advantages of utilizing a system of carbon trading permits as an alternative to implementing measures to reduce domestic levels of carbon emissions in order to meet Sweden's carbon target under the Kyoto Protocol to the United Nations Framework Construction on Climate Charge. When the benefits of only reduced carbon emissions were considered, the purchase of low-cost carbon emission permits was the more cost-effective means of meeting Sweden's targets. However, measures to reduce domestic emissions of carbon also resulted in lower emissions of sulphur and nitrogen at no extra cost. When this ancillary benefit was taken into account, the purchase of carbon emission permits was not as advantageous as measures to reduce domestic carbon emissions.

11.71. In many industrialized countries, solid waste has become a serious environmental problem, in large part because of the shortage of landfill areas in which to store waste that is increasingly harmful. Analysis of the impact of various production and consumption patterns on the generation of solid waste was discussed in chapters III and IV and also in section B of this chapter. However, increasingly, in response to external pressures, recycling and reuse within the economic process of production are an important way to reduce the use of primary materials and, consequently, to reduce the quantity of solid waste.

11.72. Capture of toxic chemicals for reuse can also reduce the levels of harmful emissions. Some industries, especially the chemical and primary metal industries, are already major on-site recyclers of materials. If the environmental protection expenditure accounts provided information about such reuse and recycling and integrated this information with physical flow accounts, they could be used, for example, to model the level of material use and solid waste associated with future economic growth and the role that recycling of specific materials could play in reducing solid waste.

D. Sustaining wealth

11.73. One of the ways of measuring sustainability is to track whether the stock of assets is being maintained over time or whether production and consumption processes diminish the stock without replacement. The ways in which such changes can be measured were described in chapter VII.

11.74. A commonly used measure of sustainability requires that total national wealth be non-decreasing over time. However, there has been a great deal of controversy over whether produced and natural capital are real substitutes for one another and thus whether they should be aggregated. Advocates of "strong sustainability" suggest that substitution and aggregation are either not possible or not appropriate: the stock of natural capital should be maintained without substituting produced capital for those elements of natural capital that are exhausted. Other commentators, however, advocate "weak sustainability" in which substitutability and aggregation of different sorts of assets is allowed (see chap. I for a broader discussion of these two concepts). As an alternative to the strong-versus-weak sustainability dichotomy, it has been proposed that some environmental assets that cannot be replaced in any meaningful way should be treated as "critical" capital and monitored separately in physical units. Substitution of other environmental assets would not pose the same order of risk.

11.75. Whether or not one chooses to aggregate the value of different forms of capital and whether or not one interprets the aggregate figure as an indicator of sustainability, it is certainly necessary for a country to monitor its wealth over time. While non-declining national wealth does not guarantee sustainable development, declining national wealth almost certainly indicates unsustainable development unless it is accompanied by technological interventions to enhance the growth rate of renewable resources or more efficient use of non-renewable resources. More comprehensive accounts for national wealth can only improve the ability of researchers and policy makers to make informed decisions.

11.76. Like the other components of the SEEA, the asset accounts provide data that can be used both for monitoring and for analysis. The present section explains the way in which the asset accounts contribute to more effective monitoring of national wealth and then discusses how the asset accounts can be used to improve management of natural capital.

1. Indicators and descriptive statistics

11.77. In order to monitor the level of national wealth, information is needed on the physical stocks of natural resources and the economic value of both produced and non-produced assets, as well as measures of the change in wealth over time and the cost of depletion.

11.78. From an ecological perspective, there are certain natural limits imposed on the use of environmental assets. Non-renewable resources, by definition, cannot be increased and all use results in depletion. The use of renewable resources cannot exceed the rate of natural growth without incurring depletion. The physical asset accounts provide indicators of ecological sustainability that are the basis for measuring strong sustainability and detailed information for the management of resources. Data on volume of mineral reserves, for example, is needed to plan extraction paths and to indicate how long a country might rely on its minerals. Data on volume of fish or forestry biomass, especially when disaggregated by age class, help determine sustainable yields and the harvesting policies appropriate to those yields.

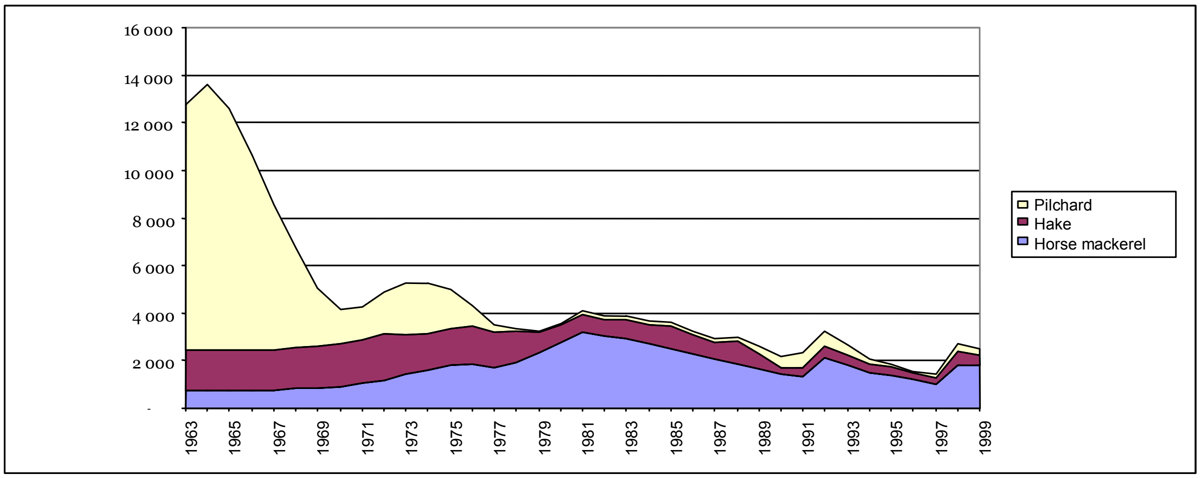
Stocks of assets in physical terms

11.79. The physical accounts provide a measure of depletion that can be useful for motivating changes in policy. For example, the biological depletion of Namibia's fish stocks since the 1960s has provided a very clear example to policy makers of the devastation resulting from uncontrolled open-access fishing. Figure 11.6 shows how the stock of pilchard fell dramatically in the 1960s and then recovered slightly in the 1970s, only to decline again. Stocks of hake have declined slowly but steadily over time and only horse mackerel has shown any continuous increase over the 1960s and 1970s.

11.80. Similar accounts of physical depletion have been constructed for tropical forests in Brazil, Malaysia, Indonesia and elsewhere. The physical accounts for water have provided important information to policy makers in France, Spain, the Republic of Moldova and Chile about availability (for example, annual available supply relative to long-term average supply) and depletion (for example, groundwater depletion, evaporation from dams) that is necessary for management.

Figure 11.6. Biomass of selected fish stocks, Namibia, 1963-1999

Thousands of tons



Source: Lange (2002).

11.81. Monitoring the potential contribution of the economy to climate change requires a physical assessment of stocks and flows of greenhouse gases. An important element in such an account is the carbon storage capacity of forests. Carbon binding is calculated as a given percentage of the estimated biomass of forests and changes in carbon stocks are estimated on the basis of changes in forest biomass. An example of this was provided for the forestry example in chapter VIII. Such accounts have been constructed for Australia and were constructed for South Africa's forests in a recent academic study (Hassan, 2002). Although carbon storage clearly has an economic value, that value is very uncertain at this time and the benefits of carbon sequestration may be best represented in physical units. Table 11.6 shows a table of this sort for Australia in the 1990s.

Table 11.6. Forest area, carbon uptake and carbon release, Australia, 1990-1998

Thousands of tons of carbon

	Area of forests, (thousands of hectares)	Total carbon uptake through annual biomass increment	Annual carbon release due to commercial harvest, other uses and clearing losses	Net annual carbon uptake (+) or release (-)
1990	15 929	19 457	12 793	6 663
1995	15 962	19 599	13 480	6 119
1996	15 996	19 742	13 746	5 995
1997	16 029	19 884	13 963	5 921
1998	16 062	20 206	14 122	5 904

Source: Government of Australia (2000).

11.82. Many countries are concerned with land-use changes, such as the loss of agricultural land to urban growth, and the conversion of forest land to agricultural land. Physical accounts for land are useful for tracking changes in land use that have important environmental and economic consequences. Chapter VIII provided a discussion of land use.

11.83. Table 11.7 gives an example of land-use change derived from Canada's land accounts, which monitor the conversion of dependable agricultural land to urban areas, roads and other non-agricultural uses. Although Canada is a very large country, 90 per cent of its population and much of its dependable agricultural land are concentrated in a relatively narrow band along its southern border. As in many countries, urban growth has often involved the conversion of agricultural land to other uses and has diminished the supply of dependable land for agricultural purposes. Between 1971 and 1996, urban land area grew by 76 per cent, while dependable agricultural land declined by 8 per cent.

Table 11.7. Land-use-change, Canada, 1971-1996

Millions of hectares

	Urban land use	**Dependable agricultural land**
1971	1.6	41
1981	1.8	41
1991	2.3	39
1996	2.8	38
Percentage change	**76**	**-8**

Source: Statistics Canada (2001).

Stocks of assets in monetary terms

11.84. The physical accounts for individual assets can be used to monitor strong sustainability and to help design resource policies. However, an assessment of natural assets that is comparable with estimates of produced assets requires that, wherever possible, the economic value of a resource also be known.

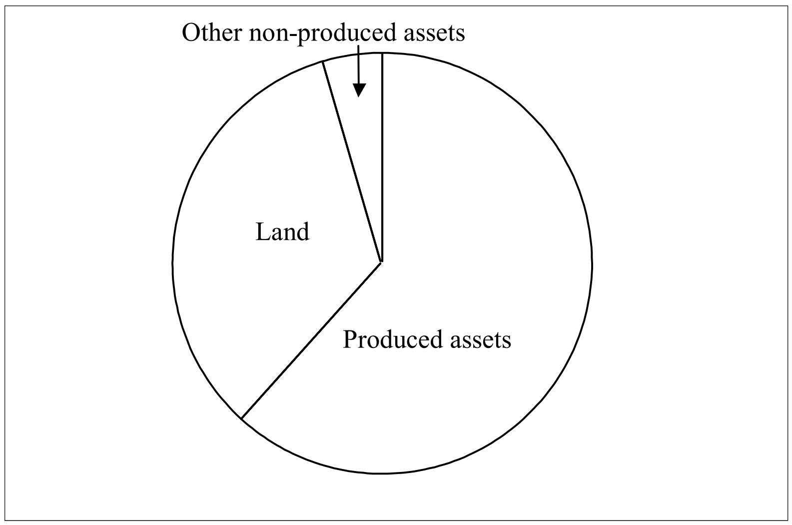
11.85. The monetary value of both produced and natural assets can be analysed to assess the diversity of wealth, its ownership distribution and its volatility due to price fluctuations (an important feature for economies dependent on primary commodities). Diversity is important because, in general, the more diverse an economy, the more resilient it will be to economic change. Understanding volatility is also important in planning for the future: lower volatility contributes to more stable economic development. The distribution of the ownership of assets between the public and private sectors and the concentration of ownership in different groups in society and in domestic versus foreign enterprises can have significant economic implications and can influence the sustainable management of resources.

11.86. Even the proponents of weak sustainability, who accept substituting other forms of capital for natural capital, caution against the use of total national wealth as an indicator of sustainability unless all assets are included. In practice, this is quite difficult because there are many environmental assets that are extremely difficult to value and there is no accepted measure for human or social capital. Where there is substitution of one type of capital for another (say, running down natural capital in order to enhance human capital by expanding education), the omission of any one type of capital from total national wealth may give policy makers a false indicator of declining sustainability. However, even if the aggregate figure for total wealth as measured may not be wholly appropriate for monitoring sustainability, it is useful to compare the economic values of different assets and how they change over time.

Composition of assets

11.87. A few countries now report figures for natural assets along with produced assets. Australia currently includes land, subsoil assets and native forests in its non-produced (natural) asset accounts. Only one of these assets, subsoil assets, is an exhaustible resource, although forests can certainly be (mis-)managed in such a way as to effect their depletion. Although Australia is considered to be a resource-rich country, the value of subsoil deposits and natural forests accounted for less than 4 per cent of total non-financial assets in 2000. Produced assets made up about two thirds of the total, with land accounting for the just under one third (see Figure 11.7).

Figure 11.7. Composition of the stock of non-financial assets, Australia, 1992



Source: Australian Bureau of Statistics (2001).

Changes over time

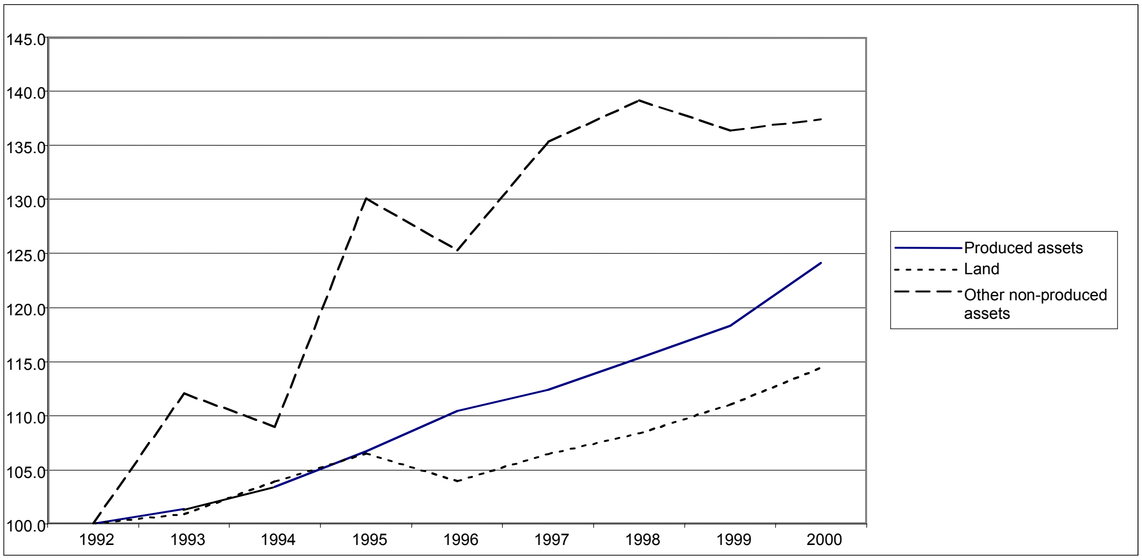
11.88. Figure 11.8 shows the change in the value of these assets in Australia over the period 1992 - 2000 expressed as index numbers based on 100 in 1992. The underlying data are expressed in constant prices.

11.89. Over the period, non-produced assets other than land increased by one third, driven by the increases in subsoil resources. Stocks of native timber declined slightly in real terms. Land increased by 16 per cent owing to the reclassification (re-zoning) of some land from rural to urban status with a consequent increase in value.

11.90. Over the same period, produced assets increased also, by about one quarter. However, while the growth in produced assets was steady over the whole time period, both land and subsoil deposits showed decreases in some years. In the case of subsoil deposits, this was due to the combined effect of depletion, discoveries and reappraisals. In the case of land, the fall in 1996 was due to a reclassification of some land between urban and rural categories.

11.91. The composition of total assets is important because, generally, a more diverse economy is more resilient. A comparison of the shares of produced and natural assets over time is one approach to monitoring progress towards diversification. The composition of total assets indicates whether depletion of natural capital is compensated for by increases in other forms of capital. While the asset structure of Australia has shown relatively little change over time, the structure of national wealth in developing countries may change very rapidly. In Botswana, for example, the share of produced capital increased from 35 to 50 per cent during the 1990s, while subsoil assets declined from 65 to 50 per cent (Lange, 2000).

Figure 11.8. Index of real growth of different classes of assets, Australia, 1992-2000



Source: Australian Bureau of Statistics (2001).

Financial assets and liabilities

11.92. The discussion so far relates to the distribution and growth of non-financial assets. In order to monitor sustainability, attention should also be paid to financial assets and liabilities. Wealth, termed "net worth" in the SNA, is defined as total assets less total liabilities. In the case of Australia, total assets increased from 1992 to 2000 by one third in real terms, whereas wealth increased by only one fifth because part of the accumulation of assets had been financed by external borrowing rather than by domestic saving.

11.93. Some resource-rich developing countries (like oil-producing countries and Botswana) are able to invest much of the income from resource exploitation in foreign assets. For such countries, net financial assets form a significant share of national wealth. It is more common, though, for developing countries to have large foreign liabilities that may more than offset the value of any exploitable natural resources. Managing a country's portfolio of assets means taking account of produced assets, natural resources and financial assets and liabilities to have a complete picture of economic resources.

Per capita measures

11.94. So far, the discussion has considered only trends in total assets and wealth. However, in most countries, population is still increasing, so a constant level of wealth and income would result in a declining per capita level of wealth and income for future generations. Inter-generational equity requires that not just total wealth, but per capita national wealth in constant prices be non-declining over time. Continuing with the Australian example, although wealth in real terms increased by 18 per cent over the period, at the same time the population increased by 9.7 per cent. Thus the increase in per capita wealth over this period was closer to 8 per cent.

Ownership

11.95. The public and private sectors may have different resource management objectives which affect the way resources are exploited. Consequently, monitoring the distribution of asset ownership between the public and private sectors may be useful, not as a direct indicator of sustainability, but as an aid to resource management. The private sector is motivated largely by commercial concerns, which can favour economic efficiency but also depletion of renewable resources under certain conditions. Government may or may not utilize resources in a sustainable way and it may use resources to achieve other socio-economic objectives, even if this lowers the economic return from a resource.

11.96. The private and public sectors, may also differ in their responses to the depletion of natural assets. Where depletion occurs, sustainability requires reinvestment in other forms of capital. Private ownership may result in reinvestment in private sector activities, but foreign ownership may result in reinvestment elsewhere which does not benefit the country providing the wealth. In countries where the government owns the resource and recovers most of the resource rent, the government bears responsibility for reinvestment, often investing in public sector capital. There is disagreement over the extent to which growth in government assets is an effective substitute for other forms of capital. There is a tendency to assume that government is economically inefficient compared with the private sector, but it is also well documented that the private sector will underinvest in assets where social benefits exceed private benefits, like public infrastructure and human capital.

11.97. Table 11.8 shows the composition of non-financial assets for Australia for 2000. The data in the first column may be compared with the information in Figure 11.7 which related to 1992 and with the growth rates of the various types of assets shown in Figure 11.8. However, a finer breakdown of assets, as well as the percentage share owned by general government, is given in Table 11.8. (This is not quite the same as covering the whole of the public sector, but data on that basis are not available.) Among produced assets, most dwellings, machinery and equipment, and livestock are in private hands. Government owns a significant share of plantation standing timber and other buildings and structures. Most of the value of non-produced assets is represented by land, none of which is owned by general government. However, all subsoil assets and most native standing timber are owned by the State.

Table 11.8. Ownership of different asset classes, Australia, 2000

Type of asset	Percentage of total non-financial assets	Percentage of asset class owned by general government
Produced assets	**62.6**	**14.8**
Dwellings	20.9	0.5
Other buildings and structures	25.8	31.6
Machinery and equipment	11.0	5.9
Livestock	0.6	0.0
Plantation standing timber	0.3	63.8
Other produced assets	4.0	5.0
Non-produced assets	**37.4**	**14.0**
Land	32.1	0.0
Subsoil assets	5.1	100.0
Native standing timber	0.1	80.0
Other non-produced assets	0.1	54.8

Source: Australian Bureau of Statistics (2001).

2. Policy analysis and strategic planning

11.98. In terms of managing natural resources, there are three main areas of interest for policy analysis: economic efficiency, the question of sustainability, and other socio-economic objectives.

11.99. As described in chapter VII, the value of natural resources stems from the resource rent that they generate in the course of production. In many countries, resources such as minerals, natural forests and capture fisheries belong, by law, to the State. As the owner of the resources, the government has a right to charge for their use by private companies. Private companies utilizing these national assets are often regulated by government to ensure that they are managed for the best interest of the citizens. From an economic perspective, that resource management is efficient, sustainable and equitable would suggest that part of the resource rent is recovered by the government and used for the benefit of all citizens, including future generations.

11.100. As discussed earlier, non-renewable resources are not physically sustainable in a strict sense but they can be judged to be economically sustainable if the resource rent received from them is reinvested in alternative forms of capital. Renewable resources, like forests and fisheries, are capable of providing an income for all future generations if managed sustainably; but in the absence of regulation or sustainable management practices, they are often subject to overexploitation and eventual exhaustion. Policy instruments to promote sustainable management include restricting harvest rates and levying fees to discourage overexploitation.

11.101. In addition to concerns about efficiency and sustainability, there could be an interest in ensuring a more equitable distribution of benefits from the use of resources between current and future generations for which purpose recovery of resource rent from commercial operations may be deployed. This is especially true for economies that rely heavily on extractive industries. Within the current generation, the resource rent can be used to support economic development that betters the lives of all citizens, not only the minority who may own companies. However, to ensure inter-generational equity, countries need to resist the pressure to consume all the income in the current period. At least some portion of the rent must be reinvested to contribute to increased well-being for future generations. Part of the discussion concerning human capital centres around whether and how far education of the present generation benefits future generations and whether this benefit is as great as the investment in other forms of capital.

Economic efficiency

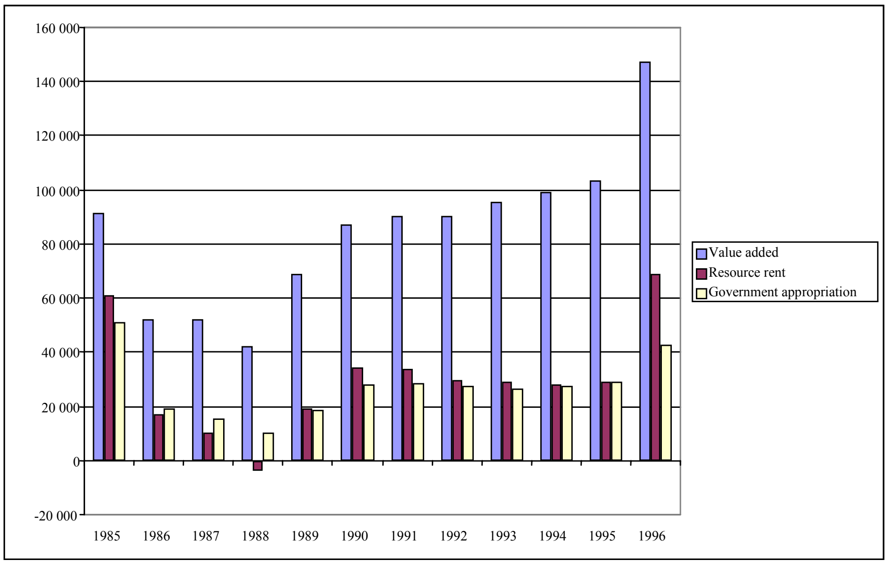
11.102. There is discussion in chapter VI on the sort of transactions that are recorded as payments by the user of an asset to its owner. When the owner is government, these payments may sometimes be referred to as taxes. In strict accounting parlance, though, these are often payments of property income, taxes being payable only when nothing is received in return. The property income payable to government for the use of natural resources can be compared with the total resource rent earned in the production process. One question of interest is whether government is recovering the whole of the resource rent; a second is whether the appropriation by government at least covers the costs of managing the industry; a third is whether current management policies maximize the amount of rent that can be generated from the resource or whether rent could be higher under an alternative management regime.

11.103. The management of three major resources in Norway - petroleum, forests and fisheries - provides an example of three very different approaches to management that affect the value of the natural assets. Figure 11.9 - Figure 11.11 show the rent generated by each of these resources and the share appropriated by government.

11.104. Figure 11.9 shows information for the oil and gas industry in Norway. Resource rent and government appropriation of this rent can be compared with the value added in the industry. The share of rent in value added has fallen over time and in 1988 rent was negative. The proportion of rent appropriated by the government remains high and in 1988 a payment was due to government even though rent was negative. Further analysis is possible by looking at the rent per unit of oil or gas extracted, as explained in chapter VII, in order to separate the effect of changing levels of unit rent from changing levels of extraction and other factors affecting the calculation of resource rent.

Figure 11.9. Resource rent and taxes from oil and gas mining, Norway, 1985-1996

Millions of Norwegian kroner

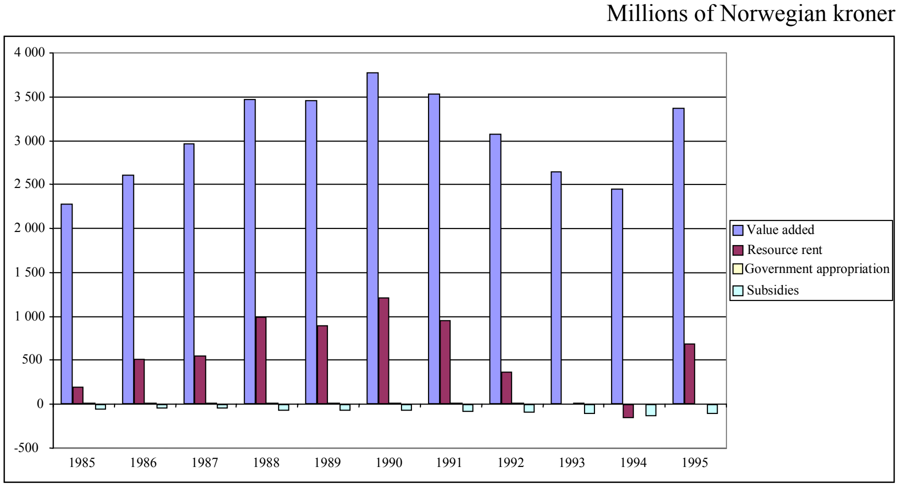


Source: Lindholt (2000).

11.105. Uncultivated forests in Norway generate substantial value added and resource rent, but since they are privately owned, the rent accrues to the private sector. Not only does government not appropriate part of this rent, but it pays some subsidies to the industry. These data series are shown in Figure 11.10.

Figure 11.10. Resource rent and taxes from forestry, Norway, 1985-1995

Millions of Norwegian kroner

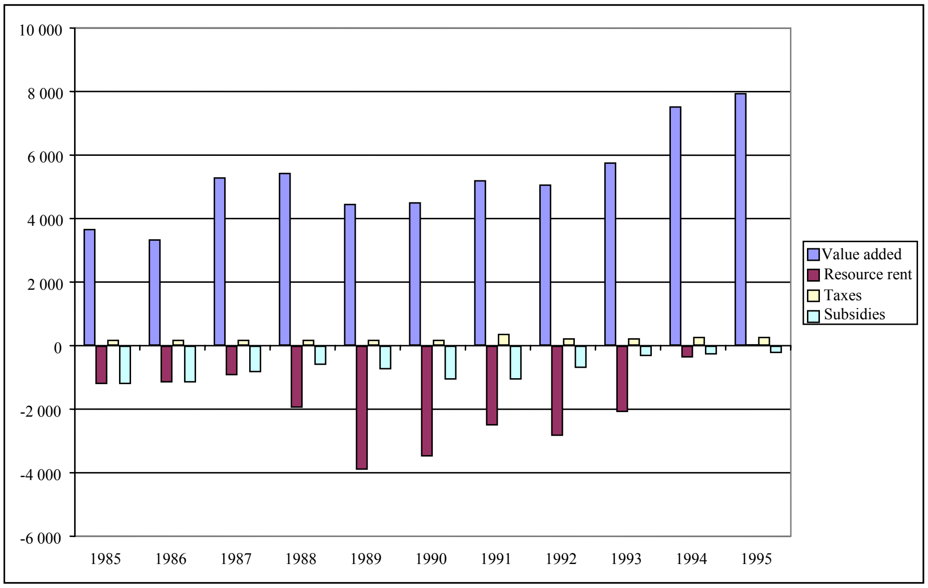


Source: Lindholt (2000).

11.106. Figure 11.11 shows that fisheries (capture fisheries plus aquaculture) in Norway are managed in such a way as to generate significant value added but no positive rent. The economic value of fish under this management regime is zero. Although small amounts of taxes are levied on the fishing industry, these payments are more than offset by subsidies. The management regime promotes exploitation of fish stocks by relatively small, inefficient vessels in order to support Norway's regional economies, an issue taken up in more detail below.

Figure 11.11. Resource rent and subsidies to fisheries, Norway, 1985-1995

Millions of Norwegian kroner



Source: Lindholt (2000).

11.107. These figures are illustrative of different management regimes. They show that different regimes may be adopted even within the same country for different resources (of course, they differ across countries). A pilot study for oil and natural gas in the Netherlands found that the Government had appropriated between 82 and 97 per cent of the rent between 1990 and 1998. The corresponding figures were generally lower in the United Kingdom: after the industry had begun to earn a positive rent in 1993, Government's share ranged from 45 to 99 per cent (Eurostat, 2000a).

11.108. In Norway, the petroleum industry is the only resource-based industry that makes a net contribution to government revenue but this contribution is still a relatively small share of total revenues. Between 1986 and 1996, it varied only between 5 and 8 per cent of the total. By contrast, in some small resource-dependent economies, government's reliance on revenues from the nation's natural resources may be quite significant. For example, the Government of Botswana receives about 50 per cent of its revenue from mining.

11.109. In assessing the contribution of natural resources to the economy, it is also useful to compare the share of resource rent in total government revenues with the share of resource management costs incurred by government. This type of analysis makes use of some of the information compiled under the environmental protection and resource management accounts discussed in chapter V. The share of the resource rent paid by the petroleum industry to government is sufficient to cover the costs of government resource management for mining in Norway in most years. Both forestry and fisheries receive net subsidies from government, so none of the costs of resource management (discussed later in this chapter) are recovered by government.

Efficiency with multiple uses of a resource

11.110. The values for assets discussed so far have been based on a single use, as represented, for example, by the timber value of forests. The full economic value of an asset and the efficient management of the asset must be based on an accounting of the full range of environmental services that can be provided by a resource. Forests may provide multiple benefits, such as timber, recreational benefits, carbon sequestration and the provision of traditional medicines and foods, which can be critical for rural populations in developing countries. In practice, comprehensive valuation may be difficult to achieve. In the example of Norwegian forest assets, only the timber value of the asset was considered. In chapter VIII, a fuller picture of the value of forests in Finland is given.

11.111. Forests in Alaska have provided substantial economic benefits to the logging, recreation and fishing industries. Economic efficiency requires assessing the optimal mix of these competing uses. Forest valuation based on timber value alone would underestimate the total economic value of the forests. Although it is more difficult to value the non-market benefits, it is increasingly important that they be valued. It is likely, for example, that the carbon sequestration value of forests will be increasingly important as progress is made on an international agreement to address climate change.

Sustainability

11.112. The issue of whether extractive industries are managed in a way that promotes sustainable development is an important one for all economies. A first question is whether the rent received from a non-renewable resource is being reinvested to maintain the level of capital stock in accordance with the principle of weak sustainability.

11.113. Aggregate figures for national wealth may indicate whether new capital formation is replacing assets that are being depleted, but they do not indicate whether there is a direct link between the revenue from the extractive industry itself and asset acquisition. When resource rent is recovered by government, it is useful to know whether the rent goes into a dedicated revenue fund used for investment and, if so, what share of the rent goes into the revenue fund and the use of that revenue fund. Some countries have such dedicated revenue funds, but they are not common.

11.114. Countries may institute their own measures to monitor the use of resource rent based on they type of information that can be provided by the SEEA. For example, Botswana, whose economy is highly dependent on mineral revenues, has developed the sustainable budget index (SBI) to indicate how much of the mineral revenues are used for capital expenditures (including spending for human capital on education and health). Although there are no strict rules for policy based on the SBI, the Government has adopted an informal fiscal guideline that no revenues from mining should be used for recurrent expenditures; in effect, all revenues from mining are reinvested. While spending under government's capital budget does not ensure that all investment is productive, the SBI is one type of indicator based on information that can be provided by the SEEA that may help to monitor sustainability.

Potential versus actual value of assets

11.115. The value of an asset depends, in part, on how efficiently it is exploited. For renewable resources, the sustainable solution is a pattern of exploitation that maximizes economic efficiency over the long run; maximizing the return to the resource and minimizing (or avoiding) depletion of the resource. Determining the maximum return depends on examining the factors that influence the partition of resource rent into an income and a depletion element, as described in chapter VII. The question arises, therefore, whether the property rights, pricing and other policies imposed by the owner (often government) promote sustainable management.

11.116. Resource management can be evaluated from the point of view of economic efficiency to determine if alternative policies might increase the income generated and hence the economic value of a resource. Another option is to maximize not income but the sustainable yield. Usually, this solution will lead to a larger stock than the income maximizing solution.

11.117. Analysis of microsurvey data of Norway's herring fishery found significant differences between large and small fishing vessels in respect of rent-earning capacity. Generally, the large-scale operations were more efficient and generated substantial rent. Assuming that most of the fishery could potentially be managed in such an efficient manner, one study of Norway's herring fishery estimated a potential resource rent of 1 billion Norwegian kroner (Flåm, 1993). However, as noted below, Norway chooses to support small-scale fishing for social reasons.

Other socio-economic objectives

11.118. Two socio-economic objectives whose pursuit may modify an approach of simple maximization of economic efficiency are that of achieving distributional equality between the present groups in society and that of achieving such equality between present and future generations.

11.119. Countries may choose to sacrifice economic efficiency in order to achieve other important socio-economic objectives. An obvious example is the case where the exploitation of a given resource is the foundation of the economy in a given region. For example, Norway has chosen to support small-scale fisheries as a component of its strategy to promote regional development. Fisheries serve as a mechanism for creating employment and generating income in parts of the country that have few options for employment. Norway is willing to sacrifice economic efficiency and the greater income that it would generate in order to achieve this goal (Sørenson and Hass, 1998).

11.120. The terms of access by foreign operators to a country's resources may have important implications for domestic employment and income, for example, in developing countries where foreign companies are invited to join the national government in exploiting a natural resource because there are insufficient financial resources and expertise available locally to do this without assistance from outside. Monitoring this situation requires estimating the share of rent that accrues to domestic operators, to government and to foreign operators. Where there are joint ventures between domestic and foreign companies, it may be difficult to determine these shares.

11.121. As pursuit of socio-economic goals that conflict with economic efficiency may have a cost, policy is more effective when this cost is known. The costs of a policy that distributes access to resources more widely in society, for example, but results in less efficient exploitation, can be measured as the resource rent that has been sacrificed and the corresponding, lower value of national wealth that results from the difference between the potential rent and the rent actually generated. An initial static analysis of the trade-off might measure this loss of rent based simply on information from microdata sets of individual companies under an existing resource management regime, as was done in the study of Norway's herring fishery. More sophisticated modelling of an industry would be required to determine the long-term economic effects of alternative management strategies on the value of a resource. Economy-wide modelling would be necessary to take into account all the changes that would result from alternative resource management policies.

11.122. As the case of Norway shows, resource management may be motivated by different objectives and result in very different outcomes in terms of efficiency, sustainability and equity. Countries may well use different resources to achieve a range of socio-economic objectives, with some resources being managed purely commercially and others not. However, in some instances, policies for managing resources may have been determined independently for each resource without the benefit of an economy-wide review that would establish a comprehensive policy for all resources. This may have occurred in the past because there was no comparable framework for measuring and analysing all resources. Such a framework is particularly important for certain resources, such as forests, that have multiple uses cutting across different economic activities. Thus, comparing the management of all resources in the common framework of the SEEA provides a valuable tool for more rational resource management.

E. How much does degradation matter?

11.123. Effective environmental management is based on an understanding not only of the physical accounts, but also of the economic implications of residuals generation and energy and material use. Policy makers need to know where limited financial resources will be most effective, that is, what the relative costs and the relative economic benefits are of reducing different forms of environmental degradation from different sources.

11.124. The issue of economic valuation of the flow accounts and the valuation methodologies were discussed extensively in chapters VII and IX. Two different conceptual approaches to valuing environmental degradation were identified: the cost approach and the damage approach. The former shows policy makers the cost of certain actions to prevent or remedy degradation and the latter shows the benefit of policy actions (that is, the value of the damages that will be prevented). In the absence of efficient markets, these measures are likely to be quite different; but both measures can be useful for environmental management, depending on the policy question that is addressed.

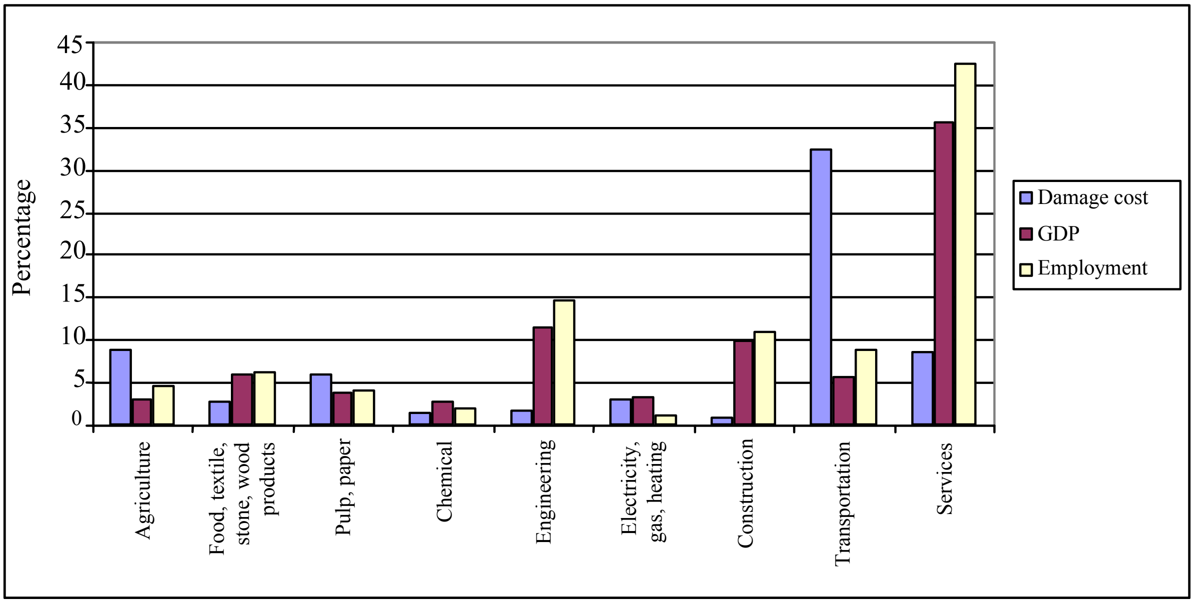
1. Indicators and descriptive statistics

11.125. The indicators derived from hybrid accounts described above show how an individual industry contributes to the economy, to employment and to the generation of residuals. It is beneficial to be able to place a value on the damage done by residuals so that the costs and benefits of economic activity and employment can be viewed in a context that includes environmental concerns as well as economic ones.

11.126. Figure 11.12 provides a snapshot for Sweden of the overall economic contribution made, and the environmental burden imposed, by each industry in 1991. The environmental burden is represented by the damages caused by domestic emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_X), volatile organic compounds (VOC), nitrogen to water, and ammonia (NH_3). The economic contribution is represented by shares of GDP (value added) and employment.

11.127. Far and away, the highest burden is that imposed by transportation, which accounts for 33 per cent of the damage costs, but only 6 per cent of national income and 9 per cent of employment. Agriculture and services are next in order in terms of damage costs, but the relative level of value added and employment contributed by services is much the highest of any industry grouping shown (36 per cent of GDP and 43 per cent of employment) whereas its environmental burden is only 9 per cent of the total damage costs. The economic contribution of the other industries, except for pulp and paper, is relatively small compared with the environmental burden that they impose. Information about relative economic contributions and environmental burdens is essential for policy makers when identifying industries that will play a key role in economic development. In the absence of such information, incentives to promote growth of a specific industry, such as subsidies to pulp and paper or agriculture, may result in levels of environmental damage that far outweigh apparent economic gains.

Figure 11.12. Economic contribution made, and environmental burden from domestic pollution imposed, by selected industries, Sweden, 1991



Source: Ahlroth (2000).

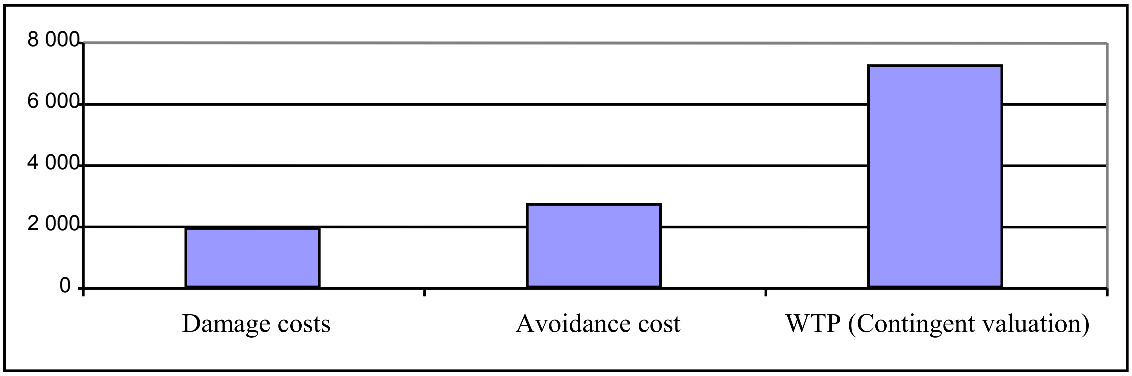
11.128. In cases where environmental policy takes the form of setting emission standards without regard for balancing economic costs and benefits, the policy challenge is to find the most cost-effective measure to meet these standards, in other words, to start with the cheapest opportunities for pollution reduction. In this case, the maintenance cost approach is useful because it provides an indication (subject to the caveats discussed in chapter X) of what it would cost to prevent or mitigate environmental degradation.

11.129. In cases where economic factors play a greater role in setting environmental policy, a cost-benefit approach might be used as an input to setting environmental priorities. In such cases, both forms of valuation are required to calculate the ratio of benefits (damages that can be prevented) to costs (costs of measures to reduce residuals). Even when cost-benefit analysis is not used in decision-making, it is still useful to know the relative costs and benefits from different actions.

11.130. Three methods of valuation have been applied to the physical accounts for NO_X in Sweden: the damage cost approach (termed repercussions on the economy in the Swedish accounts), the avoidance cost approach (one measure of maintenance cost), and willingness to pay (WTP). Figure 11.13 indicates that the damage cost approach yields the lowest value, at just over 2,000 million Swedish kronor; the value yielded by the avoidance cost approach is higher, but not very much higher, at about 2,800 million Swedish kronor. WTP yields a much higher value than either of the other two, 7,300 million Swedish kronor, which is more than three times the value obtained using the damage approach.

Figure 11.13. Damage costs, avoidance costs and willingness to pay for NO_X emissions, Sweden, 1991

Millions of Swedish kronor



Source: Ahlroth (2000).

11.131. The Philippines has constructed environmental degradation accounts for a range of pollutants to air and water from selected industries, as well as nutrient loss in agriculture and soil loss in forestry, using the maintenance cost approach. Some results from the accounts for biological oxygen demand (BOD) are shown in Table 11.9. As discussed in chapter X, the maintenance approach indicates the economic cost of reducing residuals, but not the benefits from doing so. Nonetheless, the results are instructive. Although aquaculture is responsible for 64 per cent of total BOD emissions, the cost of pollution abatement in that industry is extremely small, less than 1 per cent of total costs. By contrast, the hog industry produces 34 per cent of BOD but accounts for nearly 80 per cent of the maintenance costs. The sugar industry contributes a tiny share of total BOD emissions, only 0.4 per cent, but it would be quite costly to reduce these emissions, since its share of environmental damage costs is 13 per cent.

Table 11.9. Emissions of BOD and environmental damage, by selected industries, Philippines, 1993

Industry	Percentage of emissions	Percentage of environmental damage	Ratio of cost shares to emission shares
Aquaculture	63.7	0.7	0.01
Hog	34.2	79.7	2.33
Tuna	0.1	0.3	2.86
Textile	1.4	5.8	4.02
Leather	0.1	0.3	5.03
Sugar	0.4	13.2	31.09
Total	100.0	100.0	-
Level of emissions (metric tons) and total costs (thousands of pesos)	1 303 452	2 053 000	

Source: Philippine National Statistical Coordination Board (2000).

Note: Environmental damage was estimated using the maintenance cost approach.

Emissions of BOD were not calculated for all industries.

A hyphen (-) indicates that the item is not applicable.

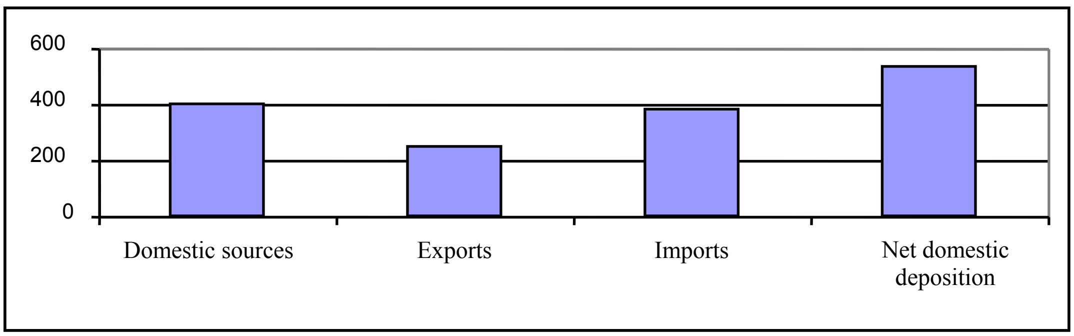
Transboundary residuals

11.132. Ideally, damage and avoidance costs would provide an indication of the relative benefits and costs of reducing emissions. However, there is not a simple correspondence between domestic environmental damage and domestic maintenance costs because of the role played by transboundary residuals. Like many countries, Sweden imports and exports a great quantity of residuals. As shown in Figure 11.14, more than 60 per cent of its domestic production of NO_X is exported, but even more (72 per cent) is imported, so that domestic deposition is 112 per cent of domestic generation.

11.133. The very high share of imported emissions indicates that Sweden will need to cooperate with neighbouring countries, which are sources of its imported NO_X, in order to improve Sweden's domestic environment. The suggestion is that it may be more cost-effective for Sweden to work with neighbouring countries to reduce their emissions and thus the imports thereof to Sweden, than to concentrate on reducing emissions in Sweden. The crude evidence from these accounts of the relative costs and benefits of reducing domestic emissions in Sweden lends further support to such an approach. However, given Sweden's considerable exports of NO_X, an efficient strategy for reducing emissions must take into account all countries involved, in order to identify in a regional context where the greatest benefits at lowest cost are to be found.

Figure 11.14. Domestic emissions, exports and imports of NO_X, Sweden, 1991

Thousands of tons



Source: Hellsten, Ribacke and Wickbom (1999).

2. Policy analysis

11.134. Valuation issues discussed in Chapter IX largely focus on environmental degradation, but policy makers can use this approach to address another challenge, namely, pricing non-market goods and environmental services. Two examples of such services that are of particular importance for developing countries are water and recreational services from nature-based protected areas. Where the costs are not recovered from users, as is the case for water in many countries, there is little incentive for resource conservation. Tourists visiting national parks and protected areas usually pay an entrance or user fee but this may not even cover the costs incurred in managing the park. Even if the costs are covered, a valuation of the recreational services and the unique ecosystems on which they depend based on entrance fees will undervalue the environmental services of the parks. Given the apparently low economic value for this form of land use, countries often face pressure to convert protected areas to other uses. This problem can be especially severe for developing countries (for example, the clearing of protected forests for agriculture in many tropical countries) but is by no means limited to them, as shown in the controversy over permitting oil extraction in Alaska's arctic wilderness.

11.135. There is an extensive literature on the economic value of protected areas, though relatively little has found its way into environmental accounts as yet. More work has been done within the accounts on the value of water. Where water rights are traded in reasonably competitive markets, as in parts of Australia, the value of water is reflected in the price of these rights. However, water is often not traded in competitive markets and its value can be difficult to measure, requiring a great deal of information that is not always readily available. Case studies in Namibia (Lange, Mac Gregor and Masirembu, 2000) for agriculture, the main user of water, found a very low value for water, though one that varied enormously by crop.

11.136. These calculations are important not only for domestic environmental policy, but also for issues that are regional or global. For example, Namibia's policy of making water available at reduced cost to commercial agriculture has changed since the early 1990s, when a policy of gradually introducing full-cost recovery was adopted. A comparison of the extent to which water was provided at less than full cost in Namibia and South Africa in 1996 (Lange and Hassan, 1999) showed that commercial agriculture in Namibia continued to benefit significantly from cheap water, though much less than commercial agriculture in South Africa. Quantifying the value of the effective subsidy has been particularly useful both in domestic discussions about water and agricultural policy and in the negotiations over future allocation of shared river water between Namibia and South Africa.

11.137. Even without estimating the economic value of water, there is monetary information about costs and tariffs which is very useful to policy makers. Flow accounts can be compiled for the cost of providing water to each sector, and the tariffs charged; from this information, the benefit of cheap water to each sector can be calculated. Monitoring effective subsidies is clearly important both for sustainable management of resources and for equity by identifying which groups in society receive the greatest assistance from them.

F. Adjusting the macroeconomic aggregates

11.138. Chapter X discussed at some length the difficulties inherent in trying to devise an accounting measure of sustainable income and explained why many commentators prefer to utilize a modelling approach that addresses the question of how to develop a sustainable economy rather than devise an aggregate referring to the economy in its present unsustainable state with adjustments for the degree of non-sustainability.

11.139. The present section describes some of the work that has been undertaken in this area. Subsection 1 deals with adjustments to national income for depletion of natural resources; subsection 2 addresses cost-based adjustments to GDP and includes reference to work conducted in trying to implement the 1993 SEEA; subsection 3 looks at experience using damage-based estimates; and subsection 4 looks at modelling approaches to estimating alternative paths for the economy. All four draw on the techniques described in chapter X.

1. Depletion adjusted macro-aggregates

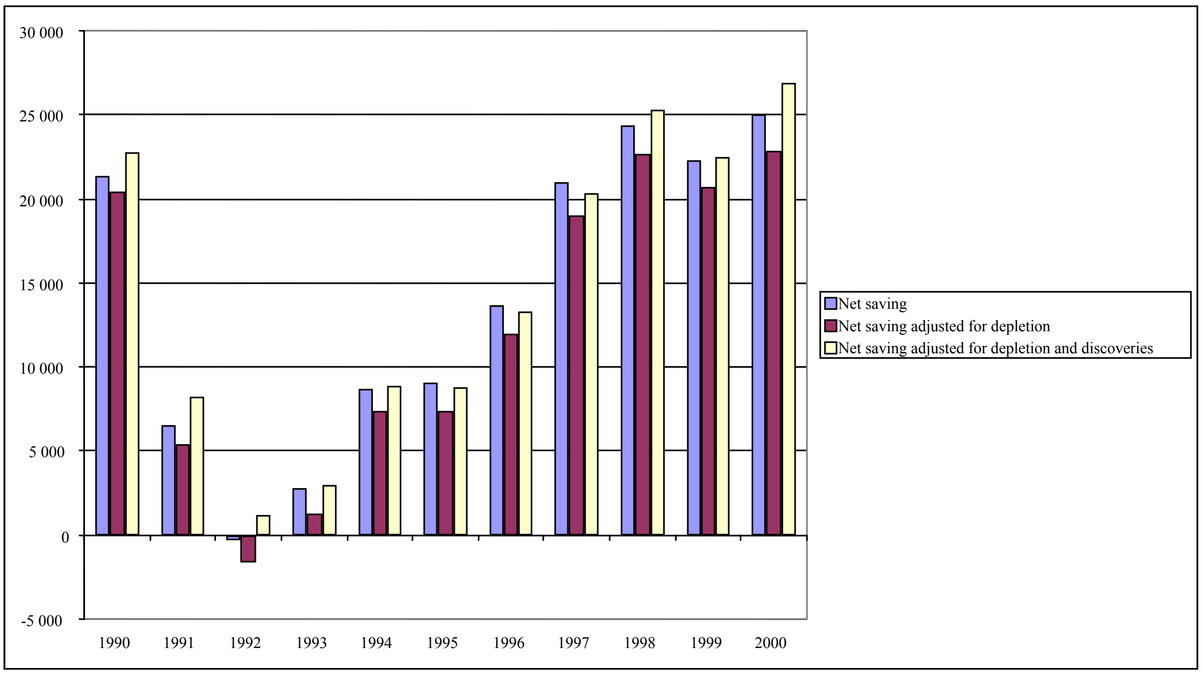
11.140. During 2001, a research paper emanating from the Australian Bureau of Statistics appeared containing adjustments that could be made to the estimates of savings and net domestic product for the depletion of subsoil resources. The techniques used for the adjusted estimates followed closely those described in chapters VII and X for the calculation of resource rent and its separation into a depletion element and an income element. Further, separate estimates were given for the case where only depletion of the resource is allowed for, as well as for the case where an addition for new discoveries was also made.

11.141. Australia has considerable mineral resources, the most valuable of which are oil and gas. However, as noted when considering the components of wealth for the country in section D above, these reserves form quite a small proportion of national wealth. It is therefore not surprising that the impact of a depletion adjustment on NDP is small, at one half of 1 per cent for each of the years from 1990 to 2000. In all these years (except for the period 1995-1997), the level of discoveries was such that NDP adjusted for both depletion and discoveries was up to one half of 1 per cent higher than NDP. For 1995, 1996 and 1997, the adjusted NDP figure was just barely lower than NDP, at 99.9 per cent in each year.

11.142. Figure 11.15 shows these changes relative to saving for each of the 10 years in question. In only one year was net saving negative. Although the adjustment for depletion exacerbates this negative amount, the compensation of including discoveries brings the adjusted saving figure back above zero.

Figure 11.15. Savings data adjusted for depletion and discoveries of natural resources, Australia, 1990-2000

Millions of Australian dollars



Source: Ryan, Johnson and Singh, 2001.

2. Cost-based estimates

11.143. An environmentally adjusted measure of domestic product was calculated in early work on environmental accounting by Repetto and his colleagues in the 1980s as a way of focusing the attention of policy makers on the importance of environmental degradation and depletion of natural capital (Repetto and others, 1989). Repetto's work in Indonesia on petroleum, forests and land degradation and in Costa Rica on forests, fisheries and land degradation was followed by similar pilot studies in the early 1990s in Papua New Guinea and Mexico sponsored by the United Nations and the World Bank.

11.144. More recently, eaNDP has been calculated for a number of countries, including Japan (Oda and others, 1998), the Republic of Korea (Korea Environment Institute, United Nations Development Programme and United Nations Statistics Division, 1998), the Philippines (Philippine National Statistical Coordination Board, 1998), Sweden (Skånberg, 2001) and Germany (Bartelmus and Vesper, 2000). There are a number of limitations associated with these studies. Not all forms of environmental degradation are included and the valuation estimates have, in some cases, been rather crude - in assuming, for example, the same cost of abatement in all industries. Some exercises are described below. The important differences between countries in terms of the types of environmental damage included and the valuation methods used make it impossible to compare results across countries directly.

Republic of Korea

11.145. Environmental accounts were constructed for the Republic of Korea over the period 1985-1992. eaNDP was calculated by subtracting from conventional NDP depletion of natural assets (minerals, forests, fish) and degradation of land, air and water. The republic of Korea used the maintenance cost approach to environmental degradation and assumed the same abatement costs in all industries. Table 11.10 shows that the resulting eaNDP was between 96 and 97 per cent of NDP over the seven-year period.

Table 11.10. eaNDP as proportion of NDP in the Republic of Korea, 1985-1992

Percentage

1985	1986	1987	1988	1989	1990	1991	1992
95.9	96.6	96.9	97.1	97.3	97.1	97.3	97.4

Source: Korea Environment Institute, United Nations Development Programme and United Nations Statistics Division (1998).

Environmental degradation due to selected economic activities in the Philippines

11.146. The Philippines also used the maintenance cost approach, but with a more realistic costing of environmental degradation. Abatement costs were estimated separately for each industry based on a consideration of the technology appropriate to each industry rather than on an assumption of the same cost in all industries. As in the Republic of Korea, the difference between NDP and eaNDP was very small.

11.147. As part of the implementation of the Philippine SEEA since 1995, the degradation due to selected economic activities was also estimated. The economic activities covered agriculture, manufacturing, gold mining, electricity generation and land (road) transportation. Fishing and forestry, upland rice growing, shrimp aquaculture, pig farming and logging were covered within agriculture. In manufacturing, the industries covered were tuna canning, sugar milling, cotton textiles, leather tanning, paint manufacturing, petroleum refining and cement.

11.148. Except for electricity generation, which is measured only in physical terms, all of the economic activities were measured in both physical and monetary terms. The prioritization of these selected economic activities was based on data availability and on experts' opinions that they were the most polluting.

Methodology

11.149. In the estimation of the environmental degradation of economic activities, the maintenance cost approach was utilized. This means that the cost of degradation of environmental media such as land, air and water was generated by using the market prices of the pollution control equipment that would have to have been installed to maintain the quality of the environment. A major assumption of the maintenance cost approach is that only the emissions that are not absorbed by the environment should be valued. However, in implementing the maintenance cost approach for the Philippines, degradation from almost all emissions and effluents was valued given that no data were available to identify which were controlled and which were uncontrolled. Hence, there was an implicit assumption that the environment could no longer absorb any of the wastes generated by these activities, with the exception of the hog and the land transport industries for which the controlled pollutants were identified.

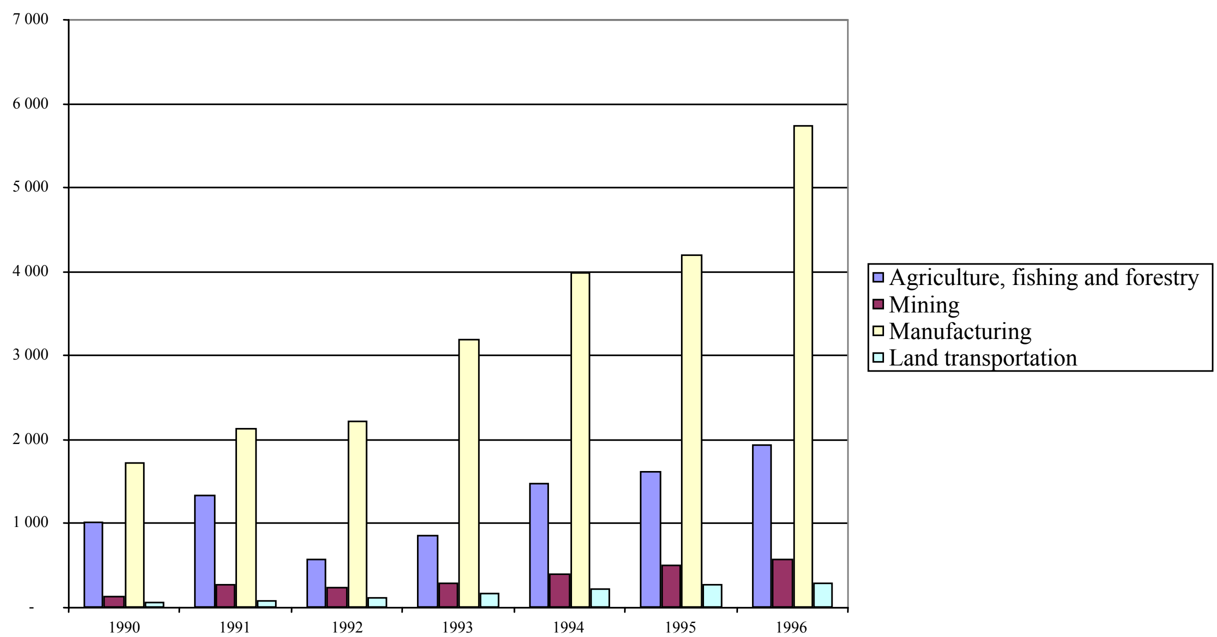
11.150. The cost of a relevant pollution control device was taken to be the sum of the annualized capital cost and the operating cost. The average cost per unit of pollutant was then calculated and applied to the level of pollutant to obtain the estimated cost of environmental degradation. In respect of some economic activities, the maintenance cost approach took the form of expenditures for avoiding the degradation such as the average cost required to avoid soil erosion and to contain mine tailings.

Key results

11.151. The degradation associated with selected economic activities is shown in Figure 11.16. The manufacturing sector was the most polluting mainly owing to the cement industry, which was the top polluter among the economic activities measured.

Figure 11.16. Cost of environmental degradation due to selected economic activities

Millions of pesos



Source: Philippine National Statistical Coordination Board (2000).

11.152. One particular use of the degradation estimates is in comparing the economic contribution and environmental burden by industry. This type of analysis could be used as a criterion for selecting what industries should be supported by the government in designing its economic development policies in connection with environmental policies; for example, the identification of growth industries could dictate the type of incentives/disincentives to be put in place. Table 11.11 shows that cement alone contributes almost 60 per cent of the degradation but only just over 1 per cent of GDP. Another three industries together contribute over 30 per cent of degradation but less than one quarter of GDP.

Table 11.11. Share of GDP and share of total degradation costs, Philippines, 1996

Industry	Percentage share of degradation costs	Percentag e share of GDP
Land transport	3.6	5.6
Upland rice farming	22.5	16.4
Small-scale gold mining	6.8	0.8
Cement manufacturing	59.3	1.3
Total for these four industries	92.2	24.1

Source: Philippine National Statistical Coordination Board (2000).

Limitations

11.153. In most estimation procedures adopted, parameters are assumed to be the same for all the years under study, since the parameters are mostly based on one-time or ad hoc surveys. Hence, trends exhibited by both the physical and monetary estimates were mostly based on the trends of the pollution base (output, input, total area and amount of wastewater generated) and the changes in the assumed trends of average cost of pollution control devices.

11.154. The use of the implicit GDP deflator for other miscellaneous durable equipment from the Philippine national accounts to extrapolate the average cost of pollution control in the manufacturing sector may not reflect the true situation, since this category may or may not include pollution control devices. The same holds true in estimating the cost of maintaining such devices.

3. Damage-based estimates

Swedish experience with damage-adjusted income

11.155. The green accounting work in Sweden has been the result of cooperation between three government agencies: Statistics Sweden, the Environmental Protection Agency, which provides physical environmental data and input-output tables, and the National Institute of Economic Research (NIER), which carries out monetary valuation. NIER has made estimates for a partially adjusted green NDP for Sweden for 1993 and 1997 (Table 11.12). The aim has been to evaluate the total value of the production of goods and services during an accounting year, including estimates of present and future negative environmental effects generated by the same production. The SNA was extended in three directions and some rearrangements were made within it, as follows:

- The resource rent from mining was subtracted applying Hartwick's rule which assumes that all resource rents from exploiting non-renewable resources are reinvested and all but the interest from the new investment is considered depreciation.
- All activities incorporated in the GDP that aimed at maintaining or improving natural capital or the expenditures that were undertaken to protect against environmental deterioration were deducted, that is, defensive expenditures were considered intermediate consumption and not final use.
- The future income losses (after the defensive expenditures undertaken) stemming from the degradation of renewable resources (forestry soils and agricultural soils) were calculated by applying market prices to modelling results presented by scientists from the fields of chemistry and the agricultural sciences.

- Damages to buildings from environmentally related corrosion were valued using dose-response functions and reinvestment costs. Real estate depreciation was estimated from official taxation values.

Table 11.12. A partially environmentally adjusted NDP for Sweden, 1993 and 1997

Millions of US dollars at 2000 prices

	1993	**1997**
NDP	180 550	202 470
Total adjustments	-1 960	-1 900
Depletion of metallic ores	*-135*	*-160*
Degradation of ecosystems	*-200*	*-190*
Exploitation of biological resources	*-15*	*-15*
Increased depreciation of produced capital	*-270*	*-205*
Expenditures aimed at maintaining natural capital	*-1 340*	*-1 330*
Environmentally adjusted domestic product (EDP)	178 587	200 568

Source: Skånberg (2001).

11.156. Note that not all environmental damages generating income losses during the accounting year are specified. According to the polluter pays principle (PPP), these income losses should be paid by the sector emitting the substances causing the damage, which could just as well be one including a firm in a foreign country. In the case of problems caused by the accumulation of residuals in the environment, the emissions affecting the Swedish environment in a given year might also be from past years. For example, it has been estimated that Swedish farmers lose 1 billion Swedish kronor annually owing to ozone damage to crops. According to the PPP, the polluting sectors, among the most important of which is the transport sector, should compensate the agricultural sector for its losses. Assuming that all emissions leading to increased ozone concentrations are of Swedish origin and from a given year, these compensation payments would affect both sectors' value added but not GDP, NDP or damage-adjusted income, as the sums cancel out.

11.157. The Swedish damage-adjusted income measure is partial in that only environmental damages caused by emissions of sulphur and nitrogen are evaluated. Some of the damages caused by these pollutants are omitted because neither the natural scientists nor the economists/statisticians have the necessary data/methods to carry out a valuation. Note, especially, that major environmental problems such as climate change, ozone depletion and loss of biodiversity are not incorporated.

Genuine saving

11.158. Chapter IX also discusses depletion-adjusted measures of national income and mentions briefly the World Bank's work on genuine saving, as reported in its *World Development Indicators* (Kunte and others, 1998; Hamilton, 2000; World Bank, 1999). This indicator is derived from modifications to the measure of savings in the existing accounts. In addition to allowance for the depletion of energy, minerals and forests and for environmental damage caused by carbon dioxide emissions, there is also an adjustment made for education expenditure, which is taken to be an important contributor to increases in human capital.

11.159. A comparison between gross domestic saving and genuine saving for different regions of the world in 1997 is given in Table 11.13. Crude assumptions were made in order to calculate this indicator for all countries. In all instances, genuine saving is less than gross domestic saving, but there is great variation among regions. In the Middle East and North Africa, genuine saving is actually negative. If genuine saving is negative at any point, it implies that social welfare will be lower at some point in future than currently, in other words, that negative genuine saving is an indicator of unsustainability. In practice, a persistent negative saving indicates that the economy is on an unsustainable path.

Table 11.13. Genuine saving in various regions of the world, 1997

	Gross domestic saving	Consumption of fixed capital	Net domestic savings	Education expenditure	Energy depletion	Mineral depletion	Net forest depletion	Carbon dioxide damage	Genuine domestic saving
World	22.2	11.7	10.5	5.0	1.2	0.1	0.1	0.4	13.6
Low-income	17.0	8.0	9.1	3.4	4.2	0.6	1.8	1.2	4.8
Middle-income	26.2	9.2	17.0	3.5	3.8	0.5	0.2	1.1	15.0
High-income	21.4	12.4	9.0	5.3	0.5	0.0	0.0	0.3	13.5
East Asia and Pacific	38.3	6.9	31.4	2.1	0.9	0.5	0.7	1.7	29.7
Europe and Central Asia	21.4	13.7	7.9	4.2	4.9	0.1	0.0	1.6	5.6
Latin America and Caribbean	20.5	8.3	12.2	3.6	2.7	0.7	0.0	0.3	12.1
Middle East and North Africa	24.1	8.8	15.3	5.2	19.7	0.1	0.0	0.9	-0.3
South Asia	18.2	9.1	9.1	3.8	2.1	0.4	2.0	1.3	7.1
Sub-Saharan Africa	16.8	9.1	7.8	4.5	5.9	1.4	0.5	0.9	3.4

Source: World Bank (1999).

4. Modelling approaches to macroeconomic indicators

11.160. As explained in chapter X, environmentally adjusted NDP is criticized for combining actual transactions (conventional GDP and NDP) with hypothetical values (monetary value of environmental degradation). If the costs of environmental mitigation had actually been paid, relative prices throughout the economy would have changed, thereby affecting economic behaviour and, ultimately, the level and structure of GDP and NDP. The response to this criticism has led to the construction of a new indicator, greened economy NDP or geNDP (or geGDP). This indicator is estimated by an economic model that internalizes the costs of environmental degradation measured in the SEEA. In fact, geGDP actually seeks to provide policy makers with guidance on how economic behaviour can be changed so as to reach a level of income that is more sustainable (more environmentally benign) than the present one.

11.161. Identifying a greened economy national income (geNI) is a complex economic modelling exercise. It requires assumptions and projections about preferences or priorities accorded to environmental functions and the corresponding environmental standards and the technological means required to achieve them, and the response to policy instruments, as well as the usual range of assumptions for an economic model including responses to changing prices by households and producers, impact on trade and so on. Different assumptions will result in very different levels of greened economy national income. Much depends on assumptions about the way in which resource use and emissions approach environmental standards and thus about the period of time over which geNI would be achieved.

11.162. A distinction can be made between geNI achievable under current conditions but with stronger preferences for environmental functions and geNI that could be achieved in a future economy with a broader range of options. The first approach has been referred to as ex post or counterfactual (O'Connor, 2001) because it attempts to estimate what the existing economy might have been if (counterfactually) it had been required to meet environmental standards. The second approach has been referred to as ex ante because it seeks to explore future economic development paths that are subject to environmental constraints. The ex post approach yields historical time-series; the ex ante approach yields forecasts. Examples of each are described below.

Hueting's sustainable national income method

11.163. Hueting's sustainable national income (SNI) method, described in chapter X, is an example of the ex post approach. The intention of the method is to obtain an impression of the difference between the income levels on the current path and those on a sustainable path. This may be interpreted as a measure of the distance between the paths in the year under review. An equally important intention is to obtain a measure of the course of welfare on the sustainable path. At the same time, the method provides information on which steps should be taken to shift to more environmentally benign activities in order that indispensable environmental functions will be available to future generations. In making these changes, only technologies known to exist (whether currently implemented or in the pipeline) are used in the model. This is in accordance with the precautionary principle. In order to value the functions and their losses, which is a prerequisite for calculating SNI, data or assumptions are needed both on the costs of the steps to restore and maintain environmental functions (the supply side) and on the preferences for those functions (the demand side).

11.164. The SNI is the maximum income that can be sustained without taking technological development into account (except for the use of non-renewable resources). In theory, the calculation should involve finding a sustainable path with maximum income within a comprehensive model of production, consumption and the environment. As yet, this is an impossible task. The calculation procedure is therefore simplified by making two assumptions:

1. The economic damage due to loss of vital environmental functions under sustainability is negligible.

2. The maximum demands on the environment that can be supported indefinitely without loss of functions will be reached when the following conditions are met:

   - Biological species may not become extinct faster than they would through natural evolution
   - Hhazards to human health are accepted only to the extent that they are comparable with those caused by other non-violent human activities
   - Environmental functions should be well distributed throughout the country and not lead to unreasonable pockets of abundance and deprivation

The resulting procedure consists of several steps, as illustrated in Figure 11.17.

11.165. Hueting's method involves setting standards for residual emissions and resource use based on scientific assessments of physical sustainability reflecting assumed preferences for sustainability. The conditions mentioned above under assumption 2 are converted into standards for the state variables of the environment. For instance, to prevent loss of species by excessive use of space and climate change, the minimum areas of land and water needed for resilient natural ecosystems and the maximum limits for the temperature of the atmosphere and its rate of change are formulated. In respect of use of space, the geographical limits to the available space are used directly as sustainability standards for this environmental problem (or theme). With the aid of models of the other relevant environmental problems, like climate change, the limits to the state variables are converted into the sustainability limits or standards for the environmental burdens (or pressures, or types of use), such as the emissions of greenhouse gases (de Boer, 2000; Hueting and de Boer, 2001).

11.166. The method further requires estimates of abatement cost curves to achieve the desired standards using currently available or foreseen technology. Where available technology is inadequate with respect to reaching the desired standards, less harmful products are substituted; if they are not available, output is reduced to the point where the standard is achieved. Sustainability standards are enforced by requiring polluters to purchase pollution rights in a market where price is determined to reflect the scarcity of these rights. SNI was calculated for the Netherlands for 1990 using a static applied general equilibrium model.

11.167. A small number of basic assumptions are made for the calculation, both in theory and in the practical procedure, some of which are relevant for the determination of the standards. First, it is assumed that the transition to sustainable activities is made in every country in the world simultaneously and in the same way. This prevents the transfer of burdening activities from one country to another. Second, sustainability standards for environmental pressures are set for the region in which they affect functions (that is, national, regional or global). As a consequence of both assumptions, a country's contribution to meeting a regional or global standard is set as equal to its contribution to regional or global pressure in the first year of the calculation.

11.168. The sustainability standards hold in the long run. They are time-dependent for non-renewable resources, with future trends in efficiency improvement, recycling possibilities and substitutes for the resource being based on observed historical development. For land use and for environmental phenomena with the characteristics of renewable resources, the pressure limits are constants.

11.169. Sustainability standards and elimination cost curves are input to a general equilibrium model of the economy. In Figure 11.17, blocks represent models (sets) of processes and lines represent variables. The order of the steps as set out in the figure is from left to right. No crossover effects between environmental problem areas are shown. The static equilibrium model maximizes the feasible SNI and optimizes the mix of technical and structural measures required. This part of the project was carried out by the Institute for Environmental Studies, Amsterdam (Verbruggen, 2000 and 2001).

11.170. Four variants of Hueting's SNI were constructed based on different assumptions about trade impacts (constant shares of output or shares that adjust as prices change) and the set of prices used to report the results. Regardless of the variant, large changes would have to occur in order to fulfil the sustainability standards in a hypothetically instantaneous moment without adaptation costs (that is, in a comparative analysis). Results are shown in Table 11.14 for major macroeconomic indicators. SNI is 56 per cent lower than national income in the base year. Household consumption declines by 49 per cent, government consumption by 69 per cent and net investment by 79 per cent. Both exports and imports fall by nearly two thirds. Production in all industries falls. Revenues from pollution rights are so high that they replace all taxes. These revenues exceed government consumption and are redistributed as lump sum payments to households to pay for consumption.

11.171. The purpose of the SNI is not to provide policy makers with a goal for national income as such, but to indicate the distance between current income and sustainable income. If this exercise were updated, with new technologies introduced into the model as they become available, Hueting's SNI would indicate whether the economy was becoming more or less sustainable over time.

Figure 11.17. Main steps in the calculation of the SNI (simplified)

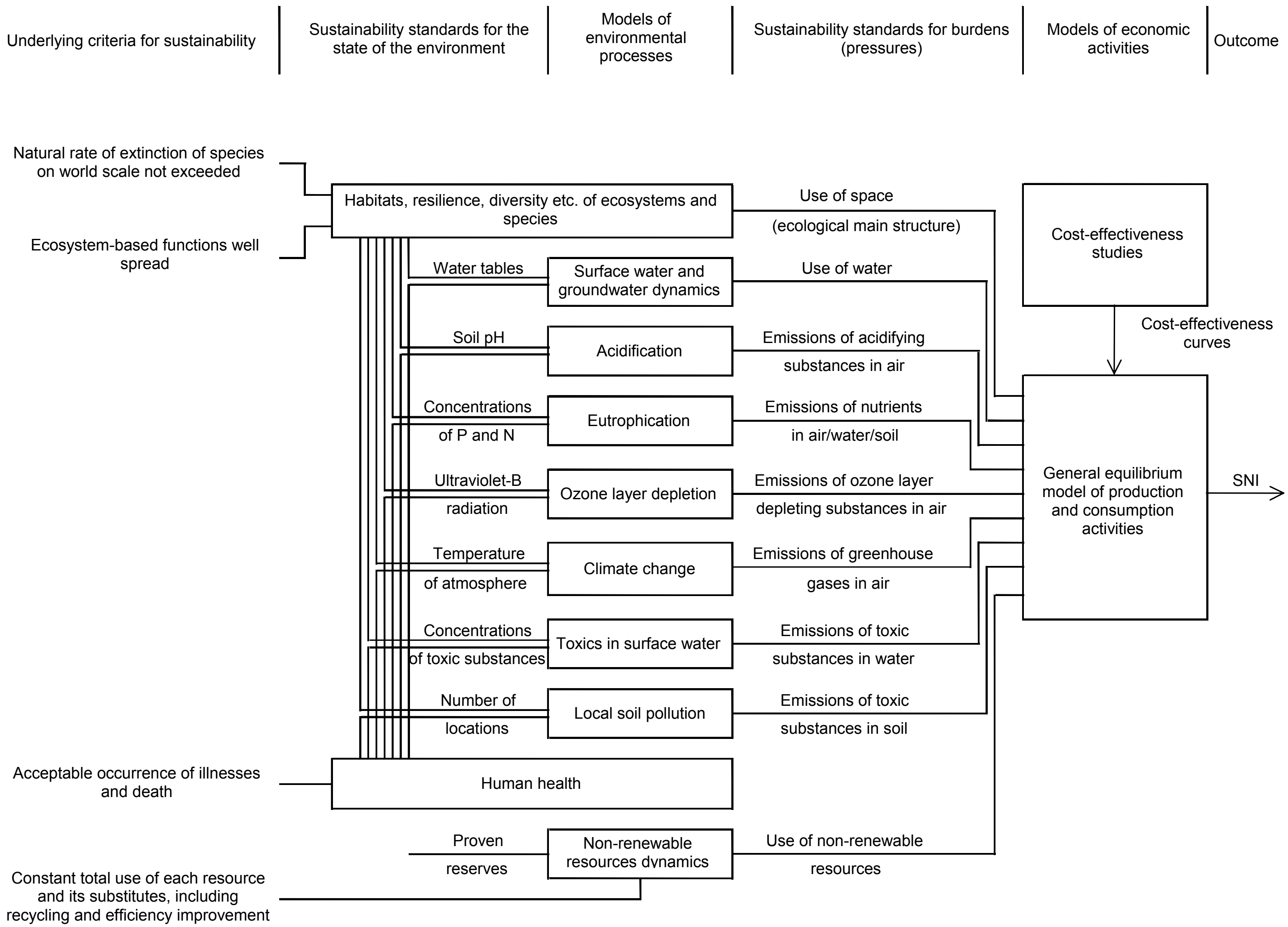


Table 11.14. Hueting's sustainable national income

Billions of guilders

	Base 1990	SNI	Change (Percentage)
National income	**457**	**201**	**-56**
Private households consumption	314	159	-49
Government consumption	75	23	-69
Net investments	51	11	-79
Trade balance	16	8	-53
Exports	229	80	-65
Imports	-213	-72	-66
National product	**457**	**201**	**-56**
Agricultural production	15	4	-76
Industrial production	113	19	-83
Services production	242	37	-85
Taxes on production	88	0	-100
Pollution rights	0	165	
Double counting	0	-24	

Source: Verbruggen and others (2000), table 7.5.

Note: SNI variant 2b: constant trade shares; new equilibrium prices.

Forward-looking estimates of geNDP

11.172. An alternative approach, the ex ante approach, estimates greened national income (geNI) by looking into a hypothetical future in which economic development must meet certain environmental standards that internalize the costs of pollution prevention or abatement. The purpose of this approach is to provide policy makers with guidance about the likely impacts of alternative development paths and the instruments for achieving them. One example of geNDP estimation occurred in a study carried out by the Swedish National Institute of Economic Research on the macroeconomic impacts of achieving different levels of reduction of CO_2 emissions. The governmental Climate Committee of Sweden is responsible for recommending target levels for greenhouse gases and also for providing a good basis for the political decisions on this matter, including estimates of the macroeconomic costs of achieving different targets.

11.173. In order to assist the Climate Committee, the Swedish National Institute of Economic Research carried out simulations for the three scenarios for reducing greenhouse gas emissions: implementation of the Kyoto Protocol for CO_2 reduction and two alternative scenarios with even greater reductions. Under the Kyoto Protocol, Sweden has agreed to stabilize CO_2 emissions at a level that is 4 per cent higher than its emissions in 1990. However, there is a widespread view in Sweden that CO_2 emissions should be reduced, hence the alternative scenarios included two more restrictive target levels: 2 or 8 per cent lower than the emissions in 1990. The latter is the same as the commitment for EU as a whole.

11.174. For these simulations, a static general equilibrium model was used with 18 production sectors including the public sector, 1 household sector and 6 types of energy inputs (from the energy accounts). The model had four mechanisms to reduce CO_2 emissions: enhancements to energy efficiency; reductions in the use of coal fuels; reduced production in coal-intensive industries (and expansion of industries that were less coal intensive); and reduced production (and consumption) overall.

11.175. The baseline scenario outlined a “business-as-usual” probable growth path for the economy up to 2010 with no restrictions on CO_2 emissions. In this case, the emissions would rise to approximately

65 million tons, which is about 17 per cent higher than the level in 1990 (56 million tons). To keep emissions within 4 per cent of emissions in 1990 would thus require a large increase of the CO_2 emission tax. In 1997, the tax rate (with exceptions for energy-intensive export sectors[39]) was 370 Swedish kronor per ton of CO_2. In the Kyoto Protocol scenario, the tax would have to be increased to 820 Swedish kronor per ton of CO_2. The changes in the economy would reduce GDP by 0.3 per cent under the +4 per cent scenario, and by 0.4 per cent and 0.6 per cent under the -2 per cent and -8 per cent scenarios, respectively. Table 11.15 shows that investment, trade and real income are significantly affected under all scenarios, but consumption much less so.

Table 11.15. Macroeconomic effects of measures to reduce carbon emissions in Sweden

	Percentage change compared with baseline scenario, 2010		
	+4 per cent scenario	-2 per cent scenario	-8 per cent scenario
GNP	-0.3	-0.4	-0.6
Private consumption	0.0	-0.1	-0.2
Public consumption	0.0	0.0	0.0
Investment	-0.4	-0.7	-1.1
Exports	-0.6	-1.0	-1.3
Imports	-0.5	-0.7	-0.9
Real income	-0.2	-0.4	-0.5

Source: Nilsson (2002).

11.176. The Climate Committee recommended that the mean value of greenhouse gas emissions (in terms of CO_2 equivalents) for the period 2008 to 2012 should be 2 per cent lower than emissions in 1990. The committee also suggested a long-term objective of reducing greenhouse gas emissions to 50 per cent of 1990 levels by the year 2050.

11.177. Estimation of geNDP varies in terms of not only the environmental issues addressed and the assumptions made, but also the type of model used. Many of the geNDP exercises have used comparative static general equilibrium models. As static models, they do not describe the dynamic path that an economy would follow to achieve the transition from the present economy to a sustainable one.

11.178. Meyer and Ewerhart (1998) addressed the greenhouse gas issue for the German economy using a different approach based on a dynamic econometric input-output model. The model was more disaggregated by industry and used the sale of carbon emission permits as a means to achieve the target levels of emission reduction by 2005 (from 5 to 30 per cent lower than Germany's emissions in 1990). A 5 per cent reduction of CO_2 emissions resulted in virtually no change in GDP, relative to the baseline scenario, but a 30 per cent reduction would reduce GDP by 3 per cent, which was still rather small. The dynamic adjustment of the economy over time (1996-2005) was not smooth, suggesting that such a model provides important information to policy makers.

11.179. No studies have yet produced geNDP indicators that are comparable across nations. This is so for several reasons. First, there are many assumptions that practitioners must make in constructing the indicators. Second, practitioners may also choose to include or ignore a wide range of environmental factors. Finally, different methodologies have been used.

[39] Manufacturing industries (pulp and paper, chemicals, refineries, iron and steel, engineering and other manufacturing industries) pay half the normal rate for the CO_2 tax, or 185 Swedish kronor/ton CO_2.

G. Indicators for sustainable development

11.180. Quite separately from the development of the SEEA, the last few years have seen an upsurge of interest in a set of indicators to measure sustainable development. There have been some initiatives to develop a single indicator to capture the essence of "sustainability". The various environmentally adjusted macroeconomic aggregates discussed in chapter IX and in section F of this chapter could be seen as candidates for the role of a single indicator. In addition, there are composite physical indicators that also claim to provide a synthetic measure of sustainability; total material requirements, as discussed in chapter III and in this chapter, constitute one such composite.

11.181. In general, though, attention has focused on assembling a set of indicators that include economic and environmental issues and also social issues to round out the picture of what sustainable development really means. Lists of indicators have been put forward by a number of national Governments and by international organizations. One such list is that of the Commission on Sustainable Development. Those indicators from the Commission's list that can be found within the SEEA are listed in Table 11.16.

Table 11.16. SEEA and the sustainable development indicators of the commission on Sustainable Development

Sustainable development indicator			Source of data in SEEA
Atmosphere			
	Climate change	Emissions of greenhouse gases	SEEA flow accounts for emissions of greenhouse gases
	Ozone layer depletion	Consumption of ozone depleting substances	SEEA flow accounts for use of ozone depleting substances
Land			
	Agriculture	Arable and permanent crop land area	Reported in land asset accounts
		Use of fertilizers	Could be reported in the physical flow accounts
		Use of agricultural pesticides	Could be reported in the physical flow accounts
	Forests	Forest area as percentage of land area	Reported in land and forest asset accounts
		Wood harvesting intensity	Reported as harvesting in the forest asset accounts
	Desertification	Land affected by desertification	Could be reported in land asset accounts
	Urbanization	Area of urban formal and informal settlements	Could be reported in land asset accounts
Oceans, seas and coasts			
	Fisheries	Annual catch, by major species	Reported in fisheries asset accounts

Fresh water		
Water quantity	Annual withdrawal of ground water and surface water as percentage of total available water	Calculated from SEEA water flow accounts.
Water quantity	BOD in water bodies	Could be calculated from SEEA water quality accounts
	Concentration of faecal coliform in freshwater	Could be calculated from SEEA water quality accounts
Biodiversity		
Ecosystem	Area of selected key ecosystems	Reported in ecosystem asset accounts
	Protected area as percentage of total area	Reported in land asset accounts and in ecosystem asset accounts
Species	Abundance of selected key species	Reported in wildlife asset accounts
Consumption and production patterns		
Material consumption	Intensity of material use	SEEA flow accounts report total material inputs; indicator can be derived by dividing GDP by total material inputs
Energy use	Annual energy consumption per capita	SEEA flow accounts report total energy use; indicator derived by dividing total energy use by population
	Share of consumption of renewable energy resources	Calculated from composition of energy flow accounts
	Intensity of energy use	SEEA flow accounts report total energy inputs; indicator can be derived by dividing GDP by total energy inputs
Waste generation and management	Generation of industrial and municipal solid waste	SEEA flow accounts for solid waste
	Generation of hazardous waste	SEEA flow accounts for specific types of waste
	Generation of radioactive waste	SEEA flow accounts for specific types of waste
	Waste recycling and reuse	SEEA flow accounts for waste, recycling and reuse

Annex I
SEEA asset classification

Asset category	Within SNA boundary	Outside SNA boundary
EA.1 Natural resources		
EA.11 Mineral and energy resources	(AN.212) [1]	[2]
EA.111 Fossil fuels (cubic metres, tons, tons of oil equivalent, joules)	(AN.2121)	
EA.112 Metallic minerals (tons)	(AN.2122)	
EA.113 Non-metallic minerals (tons)	(AN.2123)	
EA.12 Soil resources (cubic metres, tons)	Not applicable [3]	
EA.121 Agricultural		
EA.122 Non-agricultural		
EA.13 Water resources (cubic metres)		
EA.131 Surface water	Not applicable [4]	[16]
EA.1311 Artificial reservoirs		
EA.1312 Lakes		
EA. 1313 Rivers and streams		
EA.132 Groundwater	(AN.214)	
EA.14 Biological resources		
EA.141 Timber resources (cubic metres)		
EA.1411 Cultivated	(Part of AN.1221)	Not applicable
EA.1412 Non-cultivated	(Part of AN.213) [5]	[6]
EA.142 Crop and plant resources, other than timber (cubic metres, tons, number)		
EA.1421 Cultivated		Not applicable
EA.14211 Yielding repeat products (vineyards, orchards etc.)	(AN.11142)	
EA.14212 Yielding one-time harvests (crops etc.)	(Part of AN.1221)	
EA.1422 Non-cultivated	(Part of AN.213) [7]	[8]
EA.143 Aquatic resources (tons, number)		
EA.1431 Cultivated		Not applicable
EA.1432 Non-cultivated	(Part of AN.213) [9]	[10], [17]

EA.144 Animal resources, other than aquatic (number)		
EA.1441 Cultivated		Not applicable
EA.14411 Livestock for breeding purposes	(Part of AN.11141)	
EA.14412 Livestock for slaughter	(Part of AN.1221)	
EA.1442 Non-cultivated	(Part of AN.213) [11]	[12]
EA.2 Land and surface water (hectares)	**(AN.211)**	**Not applicable [13]**
Of which, recreational land	(AN.2113)	
EA.21 Land underlying buildings and structures	***(AN.2111)***	
EA.211 In urban areas		
EA.2111 For dwellings		
EA.2112 For non-residential buildings		
EA.2113 For transportation and utilities		
EA.212 Outside urban areas		
EA.2121 For dwellings		
EA.21211 Farm		
EA.21212 Non-farm		
EA.2122 For non-residential buildings		
EA.21221 Farm		
EA.21222 Non-farm		
EA.2123 For transportation and utilities		
EA.21231 Roads		
EA.21232 Railways		
EA.21233 Electric power grids		
EA.21234 Pipelines		
EA.22 Agricultural land and associated surface water	***(AN.2112)***	
EA.221 Cultivated land		
EA.2211 For temporary crops		
Of which, drained		
Of which, irrigated		
EA.2212 For permanent plantations		
Of which, drained		
Of which, irrigated		
EA.2213 For kitchen gardens		
EA.2214 Temporarily fallow land		
EA.222 Pasture land		
EA.2221 Improved		

EA.2222 Natural		
EA.223 Other agricultural land		
EA.23 Wooded land and associated surface water	***(Part of AN.2112, AN.2113 and AN.2119)***	
EA.231 Forested land		
EA.2311 Available for wood supply		
EA.2312 Not available for wood supply		
EA.232 Other wooded land		
EA.24 Major water bodies	***(Part of AN.2119)***	
EA.241 Lakes		
EA.242 Rivers		
EA.243 Wetlands		
EA.244 Artificial reservoirs		
EA.25 Other land	***(Part of AN.2119)***	
EA.251 Prairie and grassland		
EA.252 Tundra		
EA.253 Sparsely vegetated/barren land		
EA.254 Permanent snow and ice		
EA.3 Ecosystems [14, 15]	**Not applicable**	
EA.31 Terrestrial ecosystems		
EA.311 Urban ecosystems		
EA.312 Agricultural ecosystems		
EA.313 Forest ecosystems		
EA.314 Prairie and grassland ecosystems		
EA.315 Tundra ecosystems		
EA.316 Dryland ecosystems		
EA.317 Other terrestrial ecosystems		
EA.32 Aquatic ecosystems		
EA.321 Marine ecosystems		
EA.322 Coastal ecosystems		
EA.323 Riverine ecosystems		
EA.324 Lacustrine ecosystems		
EA.325 Other aquatic ecosystems		

EA.33 Atmospheric systems		
EA.M Memorandum item: intangible environmental assets		
EA.M1 Mineral exploration	(AN.1121)	Not applicable
EA.M2 Transferable licences and concessions for the exploitation of natural resources	(Part of AN.222)	
EA.M3 Tradable permits allowing the emission of residuals	(Part of AN.222)	
EA.M4 Other intangible non-produced environmental assets	(Part of AN.222)	

Note: Light shading indicates that monetary valuation is normally possible; dark shading that, while physical valuation is possible, it may be doubtful that monetary valuation is possible.

[1] The mineral and energy resource assets that fall within the SNA boundary are those that are defined as proven reserves. In practice, though, some countries may include a wider class of resources even within the SNA accounts.

[2] The mineral and energy resource assets that fall outside the SNA boundary are those that are defined as probable, possible and speculative reserves.

[3] The value of soil resources cannot be separated from the value of the land of which they form an integral part. Therefore, only the physical extent of soil resources is measured in the SEEA.

[4] The value of surface water as a natural resource cannot be separated from its value as an integral component of the national territory. Therefore, only the physical extent of surface water resources (measured in volumetric terms) is included in the natural resource category of the asset classification.

[5] The non-cultivated timber resources that fall within the SNA boundary are those that are capable of producing a merchantable stand within a reasonable period of time, are accessible for logging purposes, and are not protected from logging.

[6] The non-cultivated timber resources that fall outside the SNA boundary are those that are not suitable for timber harvesting, because of low productivity, inaccessibility and/or protection from logging.

[7] The non-cultivated crop and plant resources that fall within the SNA boundary are those that provide harvestable materials that may be traded in the market or used for subsistence purposes, that are accessible and that are not protected from harvesting.

[8] The non-cultivated crop and plant resources that fall outside the SNA boundary are those that potentially provide harvestable materials, but that are not suitable for harvesting because of inaccessibility or protection from harvesting.

[9] The non-cultivated aquatic resources that fall within the SNA boundary are those that are the target of commercial or subsistence fishers, are found within the exclusive economic zone (EEZ)

of the nation, are close enough to existing markets to be profitably exploitable and are not protected from harvesting.

[10] The non-cultivated aquatic resources that fall outside the SNA boundary are those that are potentially harvestable, but that are not currently the target of fishers because they are not of commercial or subsistence interest, are located in remote fishing zones or are protected from harvesting.

[11] The non-cultivated animal resources that fall within the SNA boundary are those that are the target of commercial, subsistence or sport hunters, are accessible for hunting and are not protected from harvest.

[12] The non-cultivated animal resources that fall outside the SNA boundary are those that are potentially harvestable, but that are not currently the target of hunters because they are not of commercial, subsistence or sport interest, are located in remote areas or are protected from harvesting.

[13] In principle, the entire national territory is included within the SNA asset boundary. For small densely populated countries, this should almost certainly be so. For large, sparsely populated countries, especially those with large areas that are remote and climatically hostile to mankind, there may be areas of land that are not thought to have any economic value. These would be included in this SEEA heading together with any recreational land not covered elsewhere.

[14] In principle, ecosystems can be measured in both monetary and physical terms. In practice, valuing these systems may be extremely difficult and physical measures may be all that is possible.

[15] Depending on the aspect of the ecosystem being measured, many different units of measure may be appropriate for describing environmental systems in physical terms. For example, biodiversity might be measured in terms of number of species or in terms of the area of suitable habitat. Waste assimilation capacity might be described in terms of the concentration of some key pollutant in the system. Other aspects will call for other units of measure.

[16] With the increasing establishment of property rights over water, valuation may in some cases be possible.

[17] Fish that are located outside a country's EEZ but over which internationally agreed quotas exist, may also be included.

Annex II
Classification of flows of natural resources and ecosystem inputs

Introduction

Physical flow accounting looks at natural resource and ecosystem inputs as a subset of the assets appearing in the SEEA asset classification shown in annex I. Only those natural resources and ecosystem inputs that are physically drawn into the economy are included. For coal, for example, the asset consists of all the known coal deposits, but only the coal extracted is relevant for physical flow accounting. Some of the SEEA assets, such as land and surface water, are used in situ and are not absorbed by the economy.

Cultivated biological resources such as timber or livestock for breeding are considered to be both natural resources and products. This double role can lead to material imbalances in physical flow accounts if care is not taken. Thus, in principle, physical flows from cultivated biological assets that fall under the products classification (as in annex III) are regarded not as natural resources or ecosystem inputs but as product flows. The growth of some cultivated assets such as timber or agricultural plants is largely the result of ecosystem inputs from the environment. These ecosystem inputs (within a gross concept) or the resulting biomass growth (within a net concept) have to be recorded as inputs from the environment. The net concept is often more convenient, as it only requires estimation of the natural growth and deduction of the reabsorption of products used to enhance natural growth (for example, nitrogen from fertilizer absorbed by plants).

In practice, it can sometimes be appropriate to treat certain cultivated products as natural resource inputs; for example, when input flows such as biomass harvest cannot be separated into those originating from cultivated and those originating from non-cultivated biological assets or when it would be difficult to estimate, or impractical to record, the ecosystem inputs for the growth of cultivated assets. For economy-wide material flow accounting, by convention the harvest of timber and crops from agriculture is regarded as flows from nature to the economy. A classification of minerals and biomass regarded as flows from the environment to the economy has been produced by Eurostat (2001a).

For practical flow accounting, the SEEA asset classification can be used as a starting point for the accounting for flows of natural resource and ecosystem inputs. The table below presents the parts of the asset classification that are relevant as a starting point in relation to physical flow accounting.

SEEA asset classification	Flows of natural resources
EA.1 Natural resources	
EA.11 Mineral and energy resources	The parts that are extracted. For energy accounting, it can be relevant to account for the calorific value (PJ) of *hydro, wind, solar and nuclear energy* and regard them as natural resources. These types of energy resources are not included in the asset classification. For energy accounts, a cross-classification that includes biological resources included under EA.14 might be used. Furthermore, an explicit distinction between renewable and non-renewable resources might be included in a classification of energy resources.
EA.12 Soil resources	The parts that are excavated.
EA.13 Water resources	The parts that are extracted. If they are subsequently sold, they become a product. Also, flows of water for own account use can be regarded as products after extraction. Sea water is not included in the asset account; but for physical flow accounting, it might be appropriate to include sea water extracted (for example, for cooling purposes).
EA.14 Biological resources	
EA.141 Timber resources	
EA.1411 Cultivated	Both the natural growth and the harvest are flows of *products*. Instead, the part of biomass growth resulting from ecosystem inputs (i.e., non-product inputs) is recorded. For some accounts, it is more practical to regard all the harvest of timber as a natural resource input.
EA.1412 Non-cultivated	The parts that are harvested.
EA.142 Crop and plant resources, other than timber	
EA.1421 Cultivated	Both the natural growth and the harvest are flows of *products*. Instead, the part of biomass growth resulting from ecosystem inputs (i.e., non-product inputs) is recorded. For some accounts, it is more practical to regard all the harvest of crop and plant resources as a natural resource input.
EA. 1422 Non-cultivated	The parts that are harvested.
EA.143 Aquatic resources	
EA.1431 Cultivated	Both the natural growth and the extraction are flows of *products*. Instead, the part of biomass growth resulting from ecosystem inputs (i.e., non-product inputs) is recorded. For some accounts, it is more practical to regard all the aquatic resources extracted as a natural

	resource input.
EA.1432 Non-cultivated	The parts that are harvested by fisheries.
EA.144 Animal resources	
EA.1441 Cultivated	Both the natural growth and the extraction are flows of *products*. Instead, the part of biomass growth resulting from ecosystem inputs (i.e., non-product inputs) is recorded. For some accounts, it is more practical to estimate the inputs from the quantity of plants taken in by grazing on land.
EA.1442 Non-cultivated	The parts that are harvested.
EA. 2 Land and surface water	Not relevant, as no extractive use takes place**.**
EA.3 Ecosystems	
EA.31 Terrestrial ecosystems EA.32 Aquatic ecosystems EA.33 Atmospheric systems	Ecosystems can be regarded as the provider of chemical substances for production of cultivated biological assets and other purposes. Thus, the input from nature for the production of cultivated biological assets (nitrogen, oxygen, carbon dioxide etc.) and other purposes (for example, the production of fertilizers using nitrogen taken from air, combustion using oxygen, desalination using sea water etc.) can be included here. Care must be taken not to include inputs that are a result of production (such as fertilizer, feeding stuff etc.) These ecosystem inputs will often have to be estimated based on the harvest of products (see under Cultivated biological assets above). Oxygen needed for combustion and other processes may be recorded as an ecosystem input to ensure that the physical accounts balance. This ecosystem input can be estimated based on the quantity of oxygen in products or in residuals (for example, the quantity of oxygen included in carbon dioxide emissions).

Source: Eurostat (2001a).

Annex III
Classification of physical product flows
(based on the Central Product Classification (CPC))

0 Agriculture, forestry and fishery products

01 Products of agriculture, horticulture and market gardening

Cereals; Vegetables; Fruit and nuts; Oil seeds and oleaginous fruit; Living plants; cut flowers and flower buds; flower seeds and fruit seeds; vegetable seeds; Beverages and spice crops; Unmanufactured tobacco; Plants used for sugar manufacturing; Raw vegetable materials n.e.c.

02 Live animals and animal products

Bovine cattle, sheep and goats, horses, asses, mules and hinnies, live; Swine, poultry and other animals, live

03 Forestry and logging products

Wood in the rough; Natural gums; other forestry products

04 Fish and other fishing products

Fishes, live, fresh or chilled; Crustaceans, not frozen; oysters; other aquatic invertebrates, live, fresh or chilled; other aquatic animals

1 Ores and minerals; electricity, gas and water

11 Coal and lignite; peat

Coal, not agglomerated; Briquettes and similar solid fuels manufactured from coal; Lignite, whether or not agglomerated; Peat

12 Crude petroleum and natural gas

Petroleum oils and oils obtained from bituminous minerals, crude; Natural gas, liquefied or in the gaseous state; Bituminous or oil shale and tar sands

13 Uranium and thorium ores

Uranium and thorium ores and concentrates

14 Metal ores

Iron ores and concentrates, other than roasted iron pyrites; Non-ferrous metal ores and concentrates (other than uranium or thorium ores and concentrates)

15 Stone, sand and clay

Monumental or building stone; Gypsum; anhydrite; limestone flux; limestone and other calcareous stone, of a kind used for the manufacture of lime or cement; Sands, pebbles, gravel, broken or crushed stone, natural bitumen and asphalt; Clays

16 Other minerals

Chemical and fertilizer minerals; Salt and pure sodium chloride; sea water; Precious and semi-precious stones; pumice stone; emery; natural abrasives; other minerals

17 Electricity, town gas, steam and hot water

Electrical energy; Coal gas, water gas, producer gas and similar gases, other than petroleum gases and other gaseous hydrocarbons; Steam and hot water

18 Water

Natural water

2 Food products, beverages and tobacco; textiles, apparel and leather products

21 Meat, fish, fruit, vegetables, oils and fats

Meat and meat products; Prepared and preserved fish; Prepared and preserved vegetables; Fruit juices and vegetable juices; Prepared and preserved fruit and nuts; Animal and vegetable oils and fats; Cotton linters; Oil-cake and other residues resulting from the extraction of vegetable fats or oils; flours and meals of oil seeds or oleaginous fruits, except those of mustard; vegetable waxes, except triglycerides; degras; residues resulting from the treatment of fatty substances or animal or vegetable waxes

22 Dairy products

Processed liquid milk and cream; other dairy products

23 Grain mill products, starches and starch products; other food products

Grain mill products; Starches and starch products; sugars and sugar syrups n.e.c.; Preparations used in animal feeding; Bakery products; Sugar; Cocoa, chocolate and sugar confectionery; Macaroni, noodles, couscous and similar farinaceous products; Food products n.e.c.

24 Beverages

Ethyl alcohol; spirits, liqueurs and other spirituous beverages; Wines; Malt liquors and malt; Soft drinks; bottled mineral waters

25 Tobacco products

Cigars, cheroots, cigarillos and cigarettes of tobacco or tobacco substitutes; other manufactured tobacco and manufactured tobacco substitutes; “homogenized” or “reconstituted” tobacco; tobacco extracts and essences

26 Yarn and thread; woven and tufted textile fabrics

Natural textile fibres prepared for spinning; Man-made textile staple fibres processed for spinning; Textile yarn and thread of natural fibres; Textile yarn and thread of man-made filaments or staple fibres; Woven fabrics (except special fabrics) of natural fibres other than cotton; Woven fabrics (except special fabrics) of cotton; Woven fabrics (except special fabrics) of man-made filaments and staple fibres; Special fabrics

27 Textile articles other than apparel

Made-up textile articles; Carpets and other textile floor coverings; Twine, cordage, ropes and cables and articles thereof (including netting); Textiles n.e.c.

28 Knitted or crocheted fabrics; wearing apparel

Knitted or crocheted fabrics; Wearing apparel, except fur apparel; Tanned or dressed furskins and artificial fur; articles thereof (except headgear)

29 Leather and leather products; footwear

Tanned or dressed leather; composition leather; Luggage, handbags and the like; saddlery and harness; other articles of leather; Footwear, with outer soles and uppers of rubber or plastics, or with uppers of leather or textile materials, other than sports footwear, footwear incorporating a protective metal toe-cap and miscellaneous special footwear; Sports footwear, except skating boots; Other footwear, except asbestos footwear, orthopaedic footwear and skating boots; Parts of footwear; removable in-soles, heel cushions and similar articles; gaiters, leggings and similar articles, and parts thereof

3 Other transportable goods, except metal products, machinery and equipment

31 Products of wood, cork, straw and plaiting materials

Wood, sawn or chipped lengthwise, sliced or peeled, of a thickness exceeding 6 mm; railway or tramway sleepers (cross-ties) of wood, not impregnated; Wood continuously shaped along any of its edges or faces; wood wool; wood flour; wood in chips or particles; Wood in the rough, treated with paint, stains, creosote or other preservatives; railway or tramway sleepers (cross-ties) of wood, impregnated; Boards and panels; Veneer sheets; sheets for plywood; densified wood; Builders' joinery and carpentry of wood (including cellular wood panels, assembled parquet panels, shingles and shakes); Packing cases, boxes, crates, drums and similar packings, of wood; cable-drums of wood; pallets, box pallets and other load boards, of wood; casks, barrels, vats, tubs and other coopers' products and parts thereof, of wood (including staves); Other products of wood; articles of cork, plaiting materials and straw

32 Pulp, paper and paper products; printed matter and related articles

Pulp, paper and paperboard; Books, brochures and leaflets (except advertising material) printed, printed maps; music, printed or in manuscript; Newspapers, journals and periodicals, appearing at least four times a week; Newspapers, journals and periodicals, appearing less than four times a week; Stamps, cheque forms, banknotes, stock certificates, postcards, greeting cards, advertising material, pictures and other printed matter; Registers, account books, notebooks, letter pads, diaries and similar articles, blotting-pads, blinders, file covers, forms and other articles of stationery, of paper or paperboard; Composed type, prepared printing plates or cylinders, impressed lithographic stones or other impressed media for use in printing

33 Coke oven products; refined petroleum products; nuclear fuel

Coke and semi-coke of coal, of lignite or of peat; retort carbon; Tar distilled from coal, from lignite or from peat, and other mineral tars; Petroleum oils and oils obtained from bituminous materials, other than crude; preparations n.e.c. containing by weight 70% or more of these oils, such oils being the basic constituents of the preparations; Petroleum gases and other gaseous hydrocarbons, except natural gas; Petroleum jelly; paraffin wax, micro-crystalline petroleum wax, slack wax, ozokerite, lignite wax, peat wax, other mineral waxes, and similar products; petroleum coke, petroleum bitumen and other residues of petroleum oils or of oils obtained from bituminous material; Radioactive elements and isotopes and compounds; alloys, dispersions, ceramic products and mixtures containing these elements, isotopes or compounds; radioactive residues; Fuel elements (cartridges), for or of nuclear reactors

34 Basic chemicals

Basic organic chemicals; Basic inorganic chemicals n.e.c.; Tanning or dyeing extracts; tannins and their derivatives; colouring matter n.e.c.; Activated natural mineral products; animal black; tall oil; terpenic oils produced by the treatment of coniferous woods; crude dipentene; crude para-cymene; pine oil; rosin and resin acids, and derivatives thereof; rosin spirit and rosin oils; rum gums; wood tar; wood tar oils; wood creosote; wood naphtha; vegetable pitch; brewers' pitch; Miscellaneous basic chemical products; Fertilizers and pesticides; Plastics in primary forms; Synthetic rubber and factice derived from oils, and mixtures thereof with natural rubber and similar natural gums, in primary forms or in plates, sheets or strip

35 Other chemical products; man-made fibres

Paints and varnishes and related products; artists' colours; ink; Pharmaceutical products; Soap, cleaning preparations, perfumes and toilet preparations; Chemical products n.e.c.; Man-made fibres

36 Rubber and plastics products

Rubber tyres and tubes; other rubber products; Semi-manufactures of plastics; Packaging products of plastics; other plastics products

37 Glass and glass products and other non-metallic products n.e.c.

Glass and glass products; Non-structural ceramic ware; Refractory products and structural non-refractory clay products; Cement, lime and plaster; Articles of concrete, cement and plaster; Monumental or building stone and articles thereof; other non-metallic mineral products n.e.c.

38 Furniture; other transportable goods n.e.c.

Furniture; Jewellery and related articles; Musical instruments; Sports goods; Games and toys; Roundabouts, swings, shooting galleries and other fairground amusements; Prefabricated buildings; other manufactured articles n.e.c.

39 Wastes or scraps

Wastes from food and tobacco industry; Non-metal wastes or scraps; Metal wastes or scraps

4 Metal products, machinery and equipment

41 Basic metals

Basic iron and steel; Rolled, drawn and folded products of iron and steel; Basic precious metals and metals clad with precious metals; Copper, nickel, aluminium, alumina, lead, zinc and tin, unwrought; Semi-finished products of copper, nickel, aluminium, lead, zinc and tin or their alloys; Other non-ferrous metals and articles thereof (including waste and scrap); cermets and articles thereof; ash and residue (except from the manufacture of iron or steel), containing metals or metallic compounds

42 Fabricated metal products, except machinery and equipment

Structural metal products and parts thereof; Tanks, reservoirs and containers of iron, steel or aluminium; Steam generators, (except central heating boilers) and parts thereof; other fabricated metal products

43 General-purpose machinery

Engines and turbines and parts thereof; Pumps, compressors, hydraulic and pneumatic power engines, and valves, and parts thereof; Bearings, gears, gearing and driving elements, and parts thereof; Ovens and furnace burners and parts thereof; Lifting and handling equipment and parts thereof; other general purpose machinery and parts thereof

44 Special-purpose machinery

Agricultural or forestry machinery and parts thereof; Machine-tools and parts and accessories thereof; Machinery for metallurgy and parts thereof; Machinery for mining, quarrying and construction, and parts thereof; Machinery for food, beverage and tobacco processing, and parts thereof; Machinery for textile, apparel and leather production, and parts thereof; Weapons and ammunition and parts thereof; Domestic appliances and parts thereof; Other special purpose machinery and parts thereof

45 Office, accounting and computing machinery

Office and accounting machinery, and parts and accessories thereof; Computing machinery and parts and accessories thereof

46 Electrical machinery and apparatus

Electric motors, generators and transformers, and parts thereof; Electricity distribution and control apparatus, and parts thereof; Insulated wire and cable; optical fibre cables; Accumulators, primary cells and primary batteries, and parts thereof; Electric filament or discharge lamps; arc lamps; lighting equipment; parts thereof; Other electrical equipment and parts thereof

47 Radio, television and communication equipment and apparatus

Electronic valves and tubes; electronic components; parts thereof; Television and radio transmitters and apparatus for line telephony or telegraphy; parts and accessories thereof; Radio broadcast and television receivers; apparatus for sound and video recording and reproducing; microphones, loudspeakers, amplifiers, etc.; reception apparatus for radio-telephony or radio-telegraphy; Parts for the goods of classes 4721 to 4733 and 4822; Audio and video records and tapes; Cards with magnetic strips or chip

48 Medical appliances, precision and optical instruments, watches and clocks

Medical and surgical equipment and orthopaedic appliances; Instruments and appliances for measuring, checking, testing, navigating and other purposes, except optical instruments; industrial process control equipment; parts and accessories thereof; Optical instruments and photographic equipment, and parts and accessories thereof; Watches and clocks, and parts thereof

49 Transport equipment

Motor vehicles, trailers and semi-trailers; parts and accessories thereof; Bodies (coachwork) for motor vehicles; trailers and semi-trailers; parts and accessories thereof; Ships; Pleasure and sporting boats; Railway and tramway locomotives and rolling stock, and parts thereof; Aircraft and spacecraft, and parts thereof; other transport equipment and parts thereof

Annex IV
Classification of residuals

Introduction

The present classification reflects the need for accounting flexibly for different kinds of residuals as outlined in chapters III, IV, VI and VII. The first three one-digit items are mainly tailored towards emission or substance accounts. The fourth and fifth one-digit items complete the classification of residuals and ensure consistency with the classification of natural resources and ecosystem inputs. These latter two items exist mainly for the purpose of mass balancing and are useful for economy-wide material flow accounts, water accounts or consistency checks. In many cases, accounts will be established either for selected substances or for some aggregate categories but usually not for the complete set of detailed items of the classification of residuals.

1. Solid waste

- 1.1 Chemical waste
- 1.2 Radioactive waste
- 1.3 Infectious biological waste (human health care etc.)
- 1.4 Metal waste
- 1.5 Non-metallic waste
  - 1.5.1 Paper waste
  - 1.5.2 Glass waste
  - 1.5.3 Rubber waste
  - 1.5.4 Plastic waste
  - 1.5.5 Other
- 1.6 Discarded equipment
- 1.7 Slurry and manure
- 1.8 Animal and vegetable waste
- 1.9 Mixed ordinary wastes
- 1.10 Common sludges
- 1.11 Mineral wastes
- 1.12 Stabilized waste
- 1.13 Other waste

2. Emissions to air

- 2.1 Carbon dioxide (CO_2)
- 2.2 Emissions of acidifying substances
  - 2.2.1 Ammonia (NH_3)
  - 2.2.2 Nitrogen oxides (as NO_2)
  - 2.2.3 Sulphur oxides (as SO_2)
- 2.3 Metal compounds

- 2.3.1 Cadmium compounds (as Cd)
- 2.3.2 Chromium compounds (as Cr)
- 2.3.3 Other (as Cu, Hg, Ni, Zn etc.)
- 2.4 Organic compounds
  - 2.4.1 NMVOC
  - 2.4.2 Methane (CH_4)
  - 2.4.3 Aromatics (benzene, dioxins, phenols, methane etc.)
- 2.5 Other residuals
  - 2.5.1 Asbestos
  - 2.5.2 Carbon monoxide (CO)
  - 2.5.3 Chlorides
  - 2.5.4 Nitrous oxide (N_2O)
  - 2.5.5 Particles
  - 2.5.6 Other

3. Emissions to water

- 3.1 Eutrophicating substances
  - 3.1.1 Nitrogen compounds (as N)
  - 3.1.2 Phosphor compounds (as P)
- 3.2 Metal compounds
  - 3.2.1 Cadmium compounds (as Cd)
  - 3.2.2 Chromium compounds (as Cr)
  - 3.2.3 Other (as Cu, Hg, Ni, Zn etc.)
- 3.3 Organic compounds
  - 3.3.1 NMVOC
  - 3.3.2 VOC
  - 3.3.3 Aromatics (benzene, dioxins, phenols, methane etc.)
- 3.4 Other residuals
  - 3.4.1 Chlorides
  - 3.4.2 Cyanides
  - 3.4.3 Fluorides
  - 3.4.4 Other compounds

4. Dissipative use of products and dissipative losses

- 4.1 Dissipative use of products
  - 4.1.1 Dissipative use on agricultural land (fertilizer etc.)
  - 4.1.2 Dissipative use on roads (thawing and grit materials)
  - 4.1.3 Dissipative use of other kind
- 4.2 Dissipative losses
  - 4.2.1 Abrasion (tyres etc.)
  - 4.2.2 Accidents with chemicals
  - 4.2.3 Erosion and corrosion of infrastructures (roads etc.)

5. Returned water and memorandum items for mass balancing

5.1 Returned water

5.2 Water vapour from combustion (H_2O)

5.2.1 From water (H_2O) contents of fuels

5.2.2 From hydrogen (H) contents of fuels

5.3 Water evaporation from products

5.4 Respiration of humans and livestock (CO_2 and water vapour)

Annex V
Classification of Environmental Protection Activities and Expenditure (CEPA 2000)

(with explanatory notes)

A. Introductory notes

CEPA 2000 is a generic, multipurpose functional classification for environmental protection. It is used for classifying not only activities but also products, actual outlays (expenditure) and other transactions. The classification unit is often determined by the units of the primary data sources that are being classified and by the presentation formats used for results. For example, the analysis of government budgets and accounts requires the coding of items of government environmental protection expenditure into CEPA. Some of these expenditure items will be transfers such as subsidies or investment grants, whereas others will be inputs into an environmental protection activity (for example, wages and salaries). The compilation of environmental expenditure accounts requires determining environmental protection activities and their output of environmental protection services by categories of CEPA.

Environmental protection activities are production activities in the sense of national accounts (see, for example, 1993 SNA para. 6.15, or ESA para. 2.103), that is, they combine resources such as equipment, labour, manufacturing techniques, information networks and products to create an output of goods or services. An activity may be a principal, secondary or ancillary activity.

CEPA is designed to classify transactions and activities whose primary purpose is environmental protection. The management of natural resources (for example, water supply) and the prevention of natural hazards (landslides, floods etc.) are not included in CEPA. Resource management and prevention of natural hazards are covered in broader frameworks (for example, SERIEE (Eurostat, 1994) and the OECD/Eurostat environment industry manual (Organisation for Economic Co-operation and Development and Eurostat 1999)). Separate classifications (for resource management, for example) should be set up so that they, together with the CEPA, would be part of a family of environment-related classifications.

Environmental protection products are:

(a) The environmental protection services produced by environmental protection activities;

(b) Adapted (cleaner) and connected products.

The expenditures recorded are the purchasers' prices of environmental protection services and connected products and the extra costs over and above a viable but less-clean alternative for cleaner products.

Expenditure for environmental protection includes outlays and other transactions related to:

(a) Inputs for environmental protection activities (energy, raw materials and other intermediate inputs, wages and salaries, taxes linked to production, consumption of fixed capital);

(b) Capital formation and the purchase of land (investment) for environmental protection activities;

(c) Outlays of users for the purchase of environmental protection products;

(d) Transfers for environmental protection (subsidies, investment grants, international aid, donations, taxes earmarked for environmental protection etc.).

For the presentation of aggregate results and indicators of expenditure, care is needed when adding up expenditure of different types. Available frameworks such as the SERIEE or the OECD/Eurostat pollution abatement and control (PAC) framework offer ways to avoid double counting of items of expenditure. In particular, they offer guidance on how to avoid mixing transfer payments with the expenditure that is financed by the transfers and purchases of environmental products with the expenditure for their production.

B. Classification structure

The level 1 structure of CEPA (one-digit) shows the *CEPA classes*. CEPA classes 1-7 are also called *(environmental) domains*. The main function of most two-digit and three-digit headings in CEPA is to guide classification into the classes. Selected two- and three-digit headings may also be used for data collection and coding as well as for publication purposes. In statistical practice, countries will have to adapt the CEPA structure to some extent so as to reflect national policy priorities, data availability and other circumstances. Examples include separate one-digit headings for traffic, international aid, energy-savings programmes, general administration of the environment and soil erosion. For international comparison purposes, the level 1 structure of CEPA should be fully adhered to.

1. General classification principles

Classification should be carried out according to the main purpose, taking into account the technical nature as well as the policy purpose of an action or activity. Multipurpose actions, activities and expenditure that address several CEPA classes should be divided by these classes. Classification under the heading "indivisible expenditure and activities" should be made only as a last resort.

Classification of individual items cannot be based solely on the technical nature of the items. For example, the purchase of double-glazed windows in warm countries will typically relate to issues of noise protection, whereas in colder countries they will be a standard energy saving device. Measures to reduce fertilizer use may primarily fall under CEPA 4 (protection of groundwater), CEPA 2 (prevention of runoff to protect surface waters) or CEPA 6 (prevention of nutrient enrichment to protect biotopes) depending on the main purpose of measures and policies. Measures against forest fires will be unimportant or serve purely economic purposes (and thus fall outside of CEPA) in some countries, whereas in others the main focus of measures taken to combat forest fires will be environmental, as related to landscape and habitat preservation, rather than protective (of a natural resource).

2. Classification of transversal and indivisible activities and expenditure

Transversal activities are research and development (R&D), administration and management as well as education, training and information. All R&D should be allocated to CEPA 8. Administration and management as well as education, training and information should, to the extent possible, be allocated to the "other activities" category in CEPA 1-7. Ideally, transversal activities would be identified separately, as well as by CEPA class, but primary data sources related to CEPA 1-7 often do not allow this. R&D, education and training or administration and management often either are not separable from other actions relating to another class (administration or training as part of waste management, for example) or cannot be split by class (in the case of R&D data collected by industry expenditure surveys, for example). If such identification problems are considered substantial, data on R&D, administration and management and on education, training and information should not be published at the two-digit level.

The classification of R&D in CEPA 8 follows the NABS 1993 (the Eurostat Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets). CEPA 8 should be used when primary data following the NABS are available from R&D statistics. When this is not the case, as other data sources employed (for example, budget analysis) may not allow a systematic separation of R&D from other actions and activities, R&D may then be included under several CEPA classes.

The above considerations will apply differently across countries, depending on the availability and level of detail of primary data sources. Often, differences in the main data sources will result in different practices for coding transversal activities and expenditure, and international comparability for these may be limited.

C. Classification of Environmental Protection Activities and Expenditure (CEPA 2000)

1. Protection of ambient air and climate

- 1.1 Prevention of pollution through in-process modifications
  - 1.1.1 For the protection of ambient air
  - 1.1.2 For the protection of climate and ozone layer
- 1.2 Treatment of exhaust gases and ventilation air
  - 1.2.1 For the protection of ambient air
  - 1.2.2 For the protection of climate and ozone layer
- 1.3 Measurement, control, laboratories and the like
- 1.4 Other activities

2. Wastewater management

- 2.1 Prevention of pollution through in-process modifications
- 2.2 Sewerage networks
- 2.3 Wastewater treatment
- 2.4 Treatment of cooling water
- 2.5 Measurement, control, laboratories and the like
- 2.6 Other activities

3. Waste management

- 3.1 Prevention of pollution through in-process modifications
- 3.2 Collection and transport
- 3.3 Treatment and disposal of hazardous waste
  - 3.3.1 Thermal treatment
  - 3.3.2 Landfill
  - 3.3.3 Other treatment and disposal
- 3.4 Treatment and disposal of non-hazardous waste
  - 3.4.1 Incineration
  - 3.4.2 Landfill

3.4.3 Other treatment and disposal

3.5 Measurement, control, laboratories and the like

3.6 Other activities

4. Protection and remediation of soil, groundwater and surface water

4.1 Prevention of pollutant infiltration

4.2 Cleaning up of soil and water bodies

4.3 Protection of soil from erosion and other physical degradation

4.4 Prevention and remediation of soil salinity

4.5 Measurement, control, laboratories and the like

4.6 Other activities

5. Noise and vibration abatement (excluding workplace protection)

5.1 Preventive in-process modifications at the source

5.1.1 Road and rail traffic

5.1.2 Air traffic

5.1.3 Industrial and other noise

5.2 Construction of anti-noise/anti-vibration facilities

5.2.1 Road and rail traffic

5.2.2 Air traffic

5.2.3 Industrial and other noise

5.3 Measurement, control, laboratories and the like

5.4 Other activities

6. Protection of biodiversity and landscapes

6.1 Protection and rehabilitation of species and habitats

6.2 Protection of natural and semi-natural landscapes

6.3 Measurement, control, laboratories and the like

6.4 Other activities

7. Protection against radiation (excluding external safety)

7.1 Protection of ambient media

7.2 Transport and treatment of high-level radioactive waste

7.3 Measurement, control, laboratories and the like

7.4 Other activities

8. Research and development

8.1 Protection of ambient air and climate

8.1.1 Protection of ambient air

8.1.2 Protection of atmosphere and climate

8.2 Protection of water

8.3 Waste

8.4 Protection of soil and groundwater

8.5 Abatement of noise and vibration

8.6 Protection of species and habitats

8.7 Protection against radiation

8.8 Other research on the environment

9. Other environmental protection activities

9.1 General environmental administration and management

9.1.1 General administration, regulation and the like

9.1.2 Environmental management

9.2 Education, training and information

9.3 Activities leading to indivisible expenditure

9.4 Activities not elsewhere classified

D. Explanatory notes and definitions

1. Protection of ambient air and climate

Protection of ambient air and climate comprises measures and activities aimed at the reduction of emissions into the ambient air or ambient concentrations of air pollutants as well as measures and activities aimed at the control of emissions of greenhouse gases and gases that adversely affect the stratospheric ozone layer.

Excluded are measures undertaken for cost-saving reasons (for example, energy saving).

1.1. Prevention of pollution through in-process modifications

This encompasses activities and measures aimed at the elimination or reduction of the generation of air pollutants through in-process modifications related to:

(a) Cleaner and more efficient production processes and other technologies (cleaner technologies);

(b) Consumption or use of "cleaner" (adapted) products.

Cleaner technologies

Prevention activities consist of replacing an existing production process by a new process designed to reduce the generation of air pollutants during production, storage or transportation (for example, fuel combustion improvement, recovery of solvents, prevention of spills and leaks through improving airtightness of equipment, reservoirs and vehicles etc.

Use of cleaner products

Prevention activities consist of modifying facilities so as to provide for the substitution of raw materials, energy, catalysts and other inputs by non- (or less) polluting products, or of treating raw materials prior to their use in order to make them less polluting (for example, desulphuration of fuel). Expenditure under this heading also includes the extra cost of the use of cleaner products (low sulphur fuels, unleaded gasoline, clean vehicles etc.).

1.2. Treatment of exhaust gases and ventilation air

These activities involve the installation, maintenance and operation of end-of-pipe equipment for the removal and reduction of emissions of particulate matter or other air-polluting substances either from the combustion of fuels or from processes using filters, dedusting equipment, catalytic converters, and post-combustion and other techniques. Also included are activities aimed at increasing the dispersion of gases so as to reduce concentrations of air pollutants.

Exhaust gases are emissions into the air, usually through exhaust pipes, stacks or chimneys, arising from the combustion of fossil fuels. Ventilation air is the exhaust from air conditioning systems of industrial establishments.

1.3. Measurement, control, laboratories and the like

These activities are aimed at monitoring the concentrations of pollutants in exhaust gases, the quality of air etc. Included are services for measurement of exhaust gases from vehicles and heating systems and the monitoring related to the ozone layer, greenhouse gases and climate change. Weather stations are excluded.

1.4. Other activities

These encompass all other activities and measures aimed at the protection of ambient air and climate, including regulation, administration, management, training, information and education activities specific to CEPA 1, when they can be separated from other activities related to the same class and from similar activities related to other environmental protection classes.

2. Wastewater management

Wastewater management comprises activities and measures aimed at the prevention of pollution of surface water through the reduction of the release of wastewater into inland surface water and sea water. It includes the collection and treatment of wastewater including monitoring and regulation activities. Septic tanks are also included.

Excluded are actions and activities aimed at the protection of groundwater from pollutant infiltration and the cleaning up of water bodies after pollution (see CEPA 4).

Wastewater is defined as water that is of no further immediate value for the purpose for which it was used or in the pursuit of which it was produced because of quality, quantity, or time of its release.

2.1. Prevention of pollution through in-process modifications

This involves activities and measures aimed at reducing the generation of surface water pollutants and wastewater through in-process modifications related to:

(a) Cleaner and more efficient production processes and other technologies (cleaner technologies);

(b) Consumption or use of "cleaner" (adapted) products.

Cleaner technologies

Prevention activities consist of replacing an existing production process by a new process designed to bring about a reduction of water pollutants or wastewater generated during production. It includes separation of networks, treatment and reuse of water used in the production process etc.

Use of cleaner products

Prevention activities consist of modifying an existing production process so as to provide for the substitution of raw materials, catalysts and other inputs by non- (or less) water polluting products.

2.2. Sewerage networks

This heading encompasses activities aimed at the operation of sewerage networks, that is, the collection and transport of wastewater from one or several users, as well as rain water, by means of sewerage networks, collectors, tanks and other means of transport (sewage vehicles etc.), including maintenance and repair.

Sewerage networks are the systems of collectors, pipelines, conduits and pumps designed to evacuate any wastewater (rain water, domestic and other wastewater) from the points of generation to either a sewage treatment plant or to a point where wastewater is discharged into surface water.

2.3. Wastewater treatment

The term wastewater treatment designates any process designed to render wastewater fit to meet applicable environmental standards or other quality norms. Three broad types of treatment (mechanical, biological and advanced treatment) are specified below. Alternative definitions of types of treatment may be used, for example, that based on removal rates for biochemical oxygen demand (BOD).

The term ***mechanical treatment of wastewater*** designates processes of a physical and mechanical nature that result in decanted effluent and separate sludge. Mechanical processes are also used in combination and/or conjunction with biological and advanced unit operations. Mechanical treatment is understood to include at least such processes as sedimentation, flotation etc. The activity is aimed at separating materials in suspension by the use of screens (large solids) or through sedimentation eventually assisted by chemicals or flotation (elimination of sand, oil, part of the sludge etc.).

Equipment includes screens for large solids, biological plants, equipment for filtration, flocculation, sedimentation; separation of oils and hydrocarbons; separation using inertia or gravity, including hydraulic and centrifugal cyclones, diaphragm floats etc.

The term ***biological treatment of wastewater*** designates processes that employ aerobic or anaerobic micro-organisms and result in decanted effluent and separate sludge containing microbial mass together with pollutants. Biological treatment processes are also used in combination and/or conjunction with mechanical and advanced unit operations. This activity is designed to eliminate pollution from oxidizable materials through the use of bacteria: activated sludge technique or anaerobic treatment for specific concentrated wastewater. Biodegradable materials are treated through the addition of bacteria-enriched sludge in open or closed tanks.

The term ***treatment of wastewater by advanced technologies*** designates processes capable of reducing the concentration of specific constituents in wastewater not normally achieved by other treatment options. Covers all unit operations that are not considered to be mechanical or biological, including, for example, chemical coagulation, flocculation and precipitation; break-point chlorinating; stripping; mixed media filtration; microscreening; selective ion exchange; activated carbon absorption; reverse osmosis; ultrafiltration; elector flotation. Advanced treatment processes may be used in combination and/or conjunction with mechanical and biological unit operations. This activity is aimed at eliminating oxidizable non-biodegradable matter at a higher level, as well as metals, nitrate, phosphorus etc. by using powerful biological or physical and chemical action. Special equipment is required for each operation of depollution.

Septic tanks are settling tanks through which wastewater is flowing and where the suspended matter is decanted as sludge. Organic matter (in the water and in the sludge) is partly decomposed by anaerobic bacteria and other micro-organisms. Maintenance services of septic tanks (emptying etc.) and other products for septic tanks (biological activators etc.) are included.

2.4. Treatment of cooling water

Treatment of cooling water encompasses processes that are used to treat cooling water to meet applicable environmental standards before releasing it into the environment. Cooling water is used to remove heat. Means, methods, facilities used may be: air cooling (extra cost compared with that of water cooling), cooling towers (to the extent that they are required to reduce pollution, as distinct from technical needs), cooling circuits for processing water from work sites and for condensing released vapour, equipment for enhancing the dispersion of cooling water on release, closed cooling circuits (extra cost), and circuits for use of cooling water for heating purposes (extra cost).

2.5. Measurement, control, laboratories and the like

This comprises activities aimed at monitoring and controlling the concentration of pollutants in wastewater and the quality of inland surface water and marine water at the place where wastewater is discharged (analysis and measurement of pollutants etc.).

2.6. Other activities

These encompass all other activities and measures aimed at wastewater management, including regulation, administration, management, training, information and education activities specific to CEPA 2, when they can be separated from other activities related to the same class and similar activities related to other environmental protection classes.

3. Waste management

The term ***waste management*** refers to activities and measures aimed at the prevention of the generation of waste and the reduction of its harmful effect on the environment, inter alia, the collection and treatment of waste, including monitoring and regulation activities. It also includes recycling and composting, the collection and treatment of low-level radioactive waste, street cleaning and the collection of public litter.

Waste comprises materials that are not prime products (that is, products made for the market) for which the generator has no further use for own purposes of production, transformation or consumption, and that he wishes to dispose of. Wastes may be generated during the extraction of raw materials, during the processing of raw materials to intermediate and final products, during the consumption of final products, and during any other human activity. Residuals recycled or reused at the place of generation are excluded. Also excluded are waste materials that are directly discharged into ambient water or air.

Hazardous waste is waste that, owing to its toxic, infectious, radioactive, flammable or other character defined by the legislator, poses a substantial actual or potential hazard to human health or living organisms. For the purposes of this definition, “hazardous waste” comprises for each country all those materials and products that are considered to be hazardous in accordance with that country’s practices. Low-level radioactive waste is included, whereas other radioactive waste is excluded (see CEPA 7).

Low-level radioactive waste is waste that, because of its low radionuclide content, does not require shielding during normal handling and transportation.

Treatment and disposal of waste

Treatment of waste encompasses refers to any process designed to change the physical, chemical, or biological character or composition of any waste in order to neutralize it, render it non-hazardous, safer for transport, or amenable to recovery or storage, or to reduce its volume. A particular waste may undergo more than one treatment process.

Composting and recycling activities for the purpose of environmental protection are included. Often, composting constitutes a waste treatment method and the resulting compost provided free of charge or at a very low price. The manufacture of compost classified in division 24 of ISIC/NACE (in particular class 2412, Manufacture of fertilizers and nitrogen compounds) is excluded.

In division 37 of ISIC Rev 3.1 ***recycling*** is defined as "the processing of waste and scrap and other articles, whether used or not, into secondary raw material. A transformation process is required, either mechanical or chemical. It is typical that, in terms of commodities, input consists of waste and scrap, the input being sorted or unsorted but normally unfit for further direct use in an industrial process, whereas the output is made fit for direct use in an industrial manufacturing process. The resulting secondary raw material is to be considered an intermediate good, with a value, but is not a final new product."

Compost and secondary raw materials (as well as products made of secondary raw materials) are not considered environmental protection products. Their use is excluded.

Disposal of waste is the final deposition of waste on the ground or underground in controlled or uncontrolled fashion, in accordance with the sanitary, environmental or security requirements.

3.1. Prevention of pollution through in-process modifications

This encompasses activities and measures aimed at eliminating or reducing the generation of solid waste through in-process modifications related to:

(a) Cleaner and more efficient production processes and other technologies (cleaner technologies);

(b) Consumption or use of "cleaner" (adapted) products.

Cleaner technologies

Prevention activities consist of replacing an existing production process by a new process designed to reduce the toxicity or volume of waste produced during the production process, including by separation and reprocessing.

Use of cleaner products

Protection activities consist of modifying or adapting the production process or facilities so as to provide for the substitution of raw materials, catalysts and other intermediate inputs by new, "adapted" inputs the use of which produces less waste or less hazardous waste.

3.2. Collection and transport

"Collection and transport of waste" is defined as the collection of waste, either by municipal services or similar institutions or by public or private corporations, and their transport to the place of treatment or disposal, including the separate collection and transport of waste fractions so as to facilitate recycling and the collection and transport of hazardous waste. Street cleaning is included for the part relating to public litter and collection of garbage from the streets. Excluded are winter services.

3.3. Treatment and disposal of hazardous waste

Treatment of hazardous waste comprises the processes of physical/chemical treatment, thermal treatment, biological treatment, conditioning of wastes, and any other relevant treatment method. Disposal of hazardous waste comprises landfill, containment, underground disposal, dumping at sea, and any other relevant disposal method.

Thermal treatment of hazardous waste refers to any process for the high-temperature oxidation of gaseous, liquid or solid hazardous wastes, converting them into gases and incombustible solid residues. The flue gases are released into the atmosphere (with or without recovery of heat and with or without cleaning) and any slag or ash produced is deposited in the landfill. The main technologies employed in the incineration of hazardous waste entail the use of the rotary kiln, liquid injection, incinerator grates, multiple chamber incinerators, and fluidized bed incinerators. Residues from hazardous waste incineration may themselves be regarded as hazardous waste. The resulting thermal energy may or may not be used for the production of steam, hot water or electric energy.

Landfill is an activity encompassing final disposal of hazardous waste in or on land in a controlled way that meets specific geologic and technical criteria.

Other treatment and disposal of hazardous waste may consist of chemical and physical treatment, containment and underground disposal.

Chemical treatment methods are used both to effect the complete breakdown of hazardous waste into non-toxic gases and, more usually, to modify the chemical properties of the waste, for example, to reduce water solubility or to neutralize acidity or alkalinity.

Physical treatment of hazardous waste: includes various methods of phase separation and solidification whereby the hazardous waste is fixed in an inert, impervious matrix. Phase separation encompasses the widely used techniques of lagooning, sludge drying in beds, and prolonged storage in tanks, air flotation and various filtration and centrifugation techniques, adsorption/desorption, and vacuum, extractive and azeotropic distillation. Solidification or fixation processes, which convert the waste into an insoluble, rock-hard material, are generally used as pre-treatment prior to landfill disposal. These techniques employ blending the waste with various reactants or organic polymerization reactions or the mixing of the waste with organic binders.

Containment is the retention of hazardous material in such a way as to effectively prevent its dispersing into the environment, or effect its release only at an acceptable level. Containment may occur in specially built containment spaces.

Underground disposal includes temporary storage or final disposal of hazardous wastes underground that meets specific geologic and technical criteria.

3.4. Treatment and disposal of non-hazardous waste

Treatment of non-hazardous waste comprises the processes of physical/chemical treatment, incineration of waste, biological treatment, and any other treatment method (composting, recycling etc.).

Incineration is the thermal treatment of waste during which chemically fixed energy of combusted matters is transformed into thermal energy. Combustible compounds are transformed into combustion gases leaving the system as flue gases. Incombustible inorganic matter remains in the form of slag and fly ash.

Disposal of non-hazardous waste comprises landfill, dumping at sea, and any other disposal method.

3.5. Measurement, control, laboratories and the like

Activities and measures aimed at controlling and measuring the generation and storage of waste, their toxicity etc.

3.6. Other activities

These encompass all other activities and measures aimed at waste management, including administration, management, training, information and educational activities specific to the class, when they can be separated from other activities related to the same class and from similar activities related to other environmental protection classes.

4. Protection and remediation of soil, groundwater and surface water

Protection and remediation of soil, groundwater and surface water encompass measures and activities aimed at the prevention of pollutant infiltration, cleaning up of soils and water bodies and the protection of soil from erosion and other physical degradation as well as from salinization. Monitoring, control of soil and groundwater pollution is included.

Excluded are wastewater management activities (see CEPA 2), as well as activities aimed at the protection of biodiversity and landscape (see CEPA 6).

4.1. Prevention of pollutant infiltration

This comprises activities and measures aimed at the reduction or elimination of polluting substances that may be applied to soil, or percolate into groundwater or run-off to surface water. Included are activities related to sealing of soils of industrial plants, installation of catchment for pollutant run-offs and leaks, strengthening of storage facilities and transportation of pollutant products.

4.2. Cleaning up of soil and water bodies

This comprises processes to reduce the quantity of polluting materials in soil and water bodies either in situ or in appropriate installations. It includes soil decontamination at former industrial sites, landfills and other "black spots", dredging of pollutants from water bodies (rivers, lakes, estuaries etc.), and decontamination and cleaning up of surface water following accidental pollution (for example, through collection of pollutants or through application of chemicals), as well as cleaning up of oil spills on land, inland surface waters and seas including coastal areas. Excludes the liming of lakes and artificial oxygenation of water bodies (see CEPA 6), and civil protection services.

Activities may consist of: measures for separating, containing and recovering deposits, extraction of buried casks and containers, decanting and restorage, installation of off-gas and liquid effluent drainage networks, soil washing by means of degasification, pumping of pollutants, removal and treatment of polluted soil, biotechnological methods capable of intervening without affecting the site (use of enzymes, bacteria etc.), physical chemistry techniques such as pervaporation and extraction using supercritical fluids, injection of neutral gases or bases to stifle internal fermentation etc.

4.3. Protection of soil from erosion and other physical degradation

This comprises activities and measures aimed at the protection of soil from erosion and other physical degradation (compacting, encrusting etc.). They may consist of programmes intended to restore the protective vegetal cover of soils, construction of anti-erosion walls etc. Measures may also consist of subsidising agricultural and grazing practices less harmful for soils and water bodies.

Excluded are activities carried out for economic reasons (for example, agricultural production or protection of settlements against natural hazards such as landslides).

4.4. Prevention and remediation of soil salinity

This comprises activities and measures aimed at the prevention and remediation of soil salinity. Concrete actions will depend on climatic, geologic and other country-specific factors. Included are actions to increase groundwater tables, for example, through increased freshwater infiltration so as to avoid infiltration of sea water into groundwater bodies, lowering of groundwater tables (when groundwater contains high levels of salts) through long-term revegetation programmes, changes in irrigation practices etc.

Excluded are measures that respond to economic purposes (agricultural production, reclamation of land from the sea etc.).

4.5. Measurement, control, laboratories and the like

This comprises all activities and measures aimed at controlling and measuring the quality and pollution of soils, groundwater and surface water, measuring the extent of soil erosion and salinization etc. Includes the operation of monitoring systems, inventories of black spots, maps and databases of groundwater and surface water quality, of soil pollution, erosion and salinity etc.

4.6. Other activities

These encompass all other activities and measures aimed at the protection and remediation of soil, groundwater and surface water, including administration, management, training, information and educational activities specific to the class, when they can be separated from other activities related to the same class and from similar activities related to other environmental protection classes.

5. Noise and vibration abatement (excluding workplace protection)

The term "***noise and vibration abatement***" refers to measures and activities aimed at the control, reduction and abatement of industrial and transport noise and vibration. Activities for the abatement of neighbourhood noise (soundproofing of dancing halls etc.) as well as activities for the abatement of noise in places frequented by the public (swimming pools etc.) are included.

Excluded is the abatement of noise and vibration for purposes of protection at the workplace.

5.1. Preventive in-process modifications at the source

These comprise activities and measures aimed at the reduction of noise and vibration from industrial equipment, vehicle motors, aircraft and ships engines, exhaust systems and brakes, or noise level due to tyre/road or wheel/rail surface contact. Includes the adaptation of equipment, vehicles (buses, trucks, or train and power units in the case of rail transport, aircraft and ships) in order to make them less noisy: soundproofing of hoods, brakes, exhaust systems etc. Includes also plant modifications, specially conceived foundations to absorb vibrations, extra cost for regrouping of buildings and/or of facilities in the interest of noise abatement, special facilities in building construction or reconstruction, equipment and machines conceived or constructed for low noise or vibrations, low-noise-level flares and burners etc.

Other preventive activities consist of noise abatement through the modification of surfaces. As noise emissions from motors, engines, exhaust systems and brakes are lowered, those from other sources becomes more important, in particular noise that originates from the contact between tyres and road surfaces. Activities consist of substituting silent asphalt, multilayered surfaces etc. for concrete.

5.2. Construction of anti-noise/anti-vibration facilities

These comprise activities and measures aimed at the installation and management of anti-noise facilities. These may be screens, embankments or hedges. They may consist of covering sections of urban motorways or railroads. In respect of industrial and vicinity noise, they may also consist of add-on facilities, covering and soundproofing of machines and piping, fuel regulation systems and sound absorption, noise screens, barriers, soundproofing of buildings, noise protective windows etc. in order to limit noise perception.

5.3. Measurement, control, laboratories and the like

These comprise activities and measures aimed at controlling the level of noise and vibration: installation and operation of stationary measurement and monitoring sites or mobile equipment in urban areas, observation networks etc.

5.4. Other activities

These comprise all other activities and measures aimed at noise and vibration abatement, including administration, management, training, information and educational activities specific to the class, when they can be separated from other activities related to the same class and from similar activities related to other classes. They also include, when separable, traffic management with noise abatement purposes (for example, lowering of speed limits, improvement of traffic flows), introduction of time and geographical restrictions for noisy vehicles, traffic detours at a distance from residential areas, creation of pedestrian areas, creation of construction-free buffer zones, restructuring of modal split (improvement of public transportation, use of bicycles). This covers a potentially large set of administrative measures that raise serious identification problems given their incorporation in integrated programmes of traffic control and urban planning and the difficulty of separating that part of measures and expenditure that, in these programmes, concern noise and vibration abatement from expenditure related to air pollution control, improvement of the living environment and traffic security.

In addition to regulation, other measures may consist of: financial incentives for the production and use of low-noise vehicles, labelling or information programmes for consumers so as to encourage the use of low-noise vehicles and the adoption of quiet driving behaviour.

6. Protection of biodiversity and landscapes

Protection of biodiversity and landscape encompasses measures and activities aimed at the protection and rehabilitation of fauna and flora species, ecosystems and habitats as well as the protection and rehabilitation of natural and semi-natural landscapes. The effecting of separation between "biodiversity" and "landscape" protection may not always be practical. For example, maintaining or establishing certain landscape types, biotopes, ecozones and related issues (hedgerows, lines of trees to re-establish "natural corridors") have a clear link to biodiversity preservation.

Excluded are the protection and rehabilitation of historic monuments or predominantly built-up landscapes, and the control of weed for agricultural purposes as well as the protection of forests against forests fire when this predominantly responds to economic factors. The establishment and maintenance of green spaces along roads and recreational structures (for example, golf courses, other sports facilities) are also excluded.

Actions and expenditure related to urban parks and gardens would not normally be included but may be related in some cases to biodiversity; in such cases, the activities and expenditure should be included.

6.1. Protection and rehabilitation of species and habitats

These comprise activities and measures aimed at the conservation, reintroduction or recovery of fauna and flora species, as well as the restoring, rehabilitation and reshaping of damaged habitats for the purpose of strengthening their natural functions, including conserving the genetic heritage, re-colonizing destroyed ecosystems, and placing bans on exploitation, trade etc. of specific animal and plant species, for protection purposes. Also includes censuses, inventories, databases, creation of gene reserves or banks, improvement of linear infrastructures (for example, underground passages or bridges for animals at highways or railways, etc.), feeding of the young, and management of special natural reserves (botany conservation areas etc.). Activities may also include the control of fauna and flora to maintain natural balances, including reintroduction of predator species and control of exotic fauna and flora that pose a threat to native fauna, flora and habitats.

Main activities are the management and development of protected areas, whatever the denomination they receive, that is, areas protected from any economic exploitation or in which the latter is subject to restrictive regulations whose explicit goal is the conservation and protection of habitats. Also included are activities for the restoration of water bodies as aquatic habitats: artificial oxygenation and lime-neutralization actions. When they have a clear protection of biodiversity-related purpose, measures and activities related to urban parks and gardens are to be included. Purchase of land for the purpose of protecting species and habitats is included.

6.2. Protection of natural and semi-natural landscapes

This comprises activities and measures aimed at the protection of natural and semi-natural landscapes so as to maintain and increase their aesthetic value and their role in biodiversity preservation. Included are the preservation of legally protected natural objects, expenditures incurred for the rehabilitation of abandoned mining and quarrying sites, renaturalization of river banks, burying of electric lines, maintenance of landscapes as the result of traditional agricultural practices that are threatened by prevailing economic conditions etc. For biodiversity and landscape protection related to agriculture, the identification of specific State aid programmes to farmers may be the only data source available. Protection of forests against forest fires for landscape protection purposes is included.

Excluded are measures taken in order to protect historic monuments, and measures to increase aesthetic values for economic purposes (for example, re-landscaping to increase the value of real estate) as well as protection of predominantly built-up landscapes.

6.3. Measurement, control, laboratories and the like

These encompass measurement, monitoring and analysis activities that are not classified under the preceding items. In principle, inventories of fauna and flora are not covered, since they are classified under protection of species.

6.4. Other activities

These comprise all other activities and measures aimed at the protection of biodiversity and landscape. It includes administration, training, information and educational activities specific to the domain, when they can be separated from other activities related to the same domain and similar activities related to other classes.

7. Protection against radiation (excluding external safety)

Protection against radiation encompasses activities and measures aimed at the reduction or elimination of the negative consequences of radiation emitted from any source. Included are the handling, transportation and treatment of high-level radioactive waste, that is, waste that, because of its high radionuclide content, requires shielding during normal handling and transportation.

Excluded are activities and measures related to the prevention of technological hazards (for example, external safety of nuclear power plants), as well as protection measures taken at workplaces. Also excluded are activities related to collection and treatment of low-level radioactive waste (see CEPA 3).

Definition of radioactive waste

Radioactive waste is any material that contains or is contaminated by radionuclides at concentrations or radioactivity levels greater than the "exempt quantities" established by the competent authorities, and for which no use is foreseen. Radioactive wastes are produced at nuclear power plants and at associated nuclear fuel cycle facilities as well as through other uses of radioactive material, for example, the use of radionuclides in hospitals and research establishments. Other important wastes are those from mining and milling of uranium and from the reprocessing of spent fuel.

7.1. Protection of ambient media

Protection of ambient media groups together activities and measures undertaken in order to protect ambient media from radiation. It may consist of protecting measures such as screening, creation of buffer zones etc.

7.2. Transport and treatment of high-level radioactive waste

These encompass any process designed for the transport, conditioning, containment or underground disposal of high-level radioactive waste.

Collection and transport of high-level radioactive waste consist of the collection of high-level radioactive waste, generally by specialized firms, and their transport to the place of treatment, conditioning, storage and disposal.

Conditioning of high-level radioactive waste consists of activities that transform high-level radioactive waste so that it is in proper and fit condition for transport and/or storage and/or disposal. Conditioning may occur as part of ISIC/NACE 23 (Class 2330, Processing of nuclear fuels) activities.

Containment of high-level radioactive waste designates the retention of radioactive waste in such a way as to effectively prevent its dispersal into the environment, or effect its release only at an acceptable level. Containment may occur in specially built containment spaces.

Underground disposal of high-level radioactive waste is the temporary storage or final disposal of high-level radioactive waste in underground sites that meet specific geologic and technical criteria.

7.3. Measurement, control, laboratories and the like

Activities aimed at measuring, controlling and monitoring ambient radioactivity and radioactivity due to the presence of high-level radioactive waste by means of specific equipment, instruments and installations.

7.4. Other activities

These comprise all other activities and measures aimed at the protection of ambient media against radiation, and transport and treatment of high-level radioactive waste, including administration, training, information and educational activities specific to the domain, when they can be separated from other activities related to the same class and similar activities related to other environmental protection classes.

8. Research and development

Research and development (R&D) comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge and the use of this knowledge to devise new applications (see OECD, 1994b) in the field of environmental protection.

The class regroups all R&D activities and expenditure oriented towards environmental protection, encompassing identification and analysis of sources of pollution, and mechanisms of dispersion of pollutants in the environment as well as their effects on human beings, the species and the biosphere. This heading covers R&D for the prevention and elimination of all forms of pollution, as well as R&D oriented towards developing equipment and instruments of pollution measurement and analysis. When separable, all R&D activities, even when referring to a specific class, have to be classified under this heading.

Environmental R&D is further classified in accordance with the 1993 NABS.

Excluded are R&D activities related to the management of natural resources.

9. Other environmental protection activities

Other environmental protection activities comprise all environmental protection activities that take the form of general environmental administration and management activities or training or teaching activities specifically oriented towards environmental protection or that encompass public information, when they are not classified elsewhere in the CEPA. They also include activities leading to indivisible expenditure, as well as activities not elsewhere classified.

9.1. General environmental administration and management

General administration of the environment designates any identifiable activity that is directed towards the general support of decisions taken in the context of environmental protection activities, whether by governmental or by non-governmental units.

General administration of the environment, regulation and the like

This encompasses any identifiable activity within general government and non profit institutions serving households (NPISH) units that is directed towards the regulation or administration of the environment and the support of decisions taken in the context of environmental protection activities. When possible, such activities should be allocated to other classes. If this is impossible, they should be included under this heading of the classification.

Environmental management

This encompasses any identifiable activity of corporations that is directed towards the general support of decisions taken in the context of environmental protection activities, including the preparation of declarations or requests for permission, internal environmental management, and environmental certification processes Internal Organization for Standardization (ISO) 14000, European Eco-Management and Audit Scheme (EMAS), as well as the recourse to environmental consultancy services. Activities of units specializing in environmental consultancy, supervision and analysis are included. When possible, such activities should be allocated to other CEPA classes.

9.2. Education, training and information

These comprise activities that aim at providing general environmental education or training and disseminating environmental information. Included are high school programmes, university degree programmes or special courses specifically aimed at training for environmental protection. Activities such as the production of environmental reports, environmental communication etc. are also included.

9.3. Activities leading to indivisible expenditure

These comprise environmental protection activities that lead to indivisible expenditure, that is, those that cannot be allocated to any other CEPA class. International financial aid may be a case in point, as it may be difficult for the donor countries to attribute international aid to individual classes. If international aid is important in volume and/or of specific political interest, a separate two-digit heading under CEPA 9 could be adequate for national purposes.

9.4. Activities not elsewhere classified

This heading groups together all these environmental protection activities that cannot be classified under other headings of the classification.

Annex VI
SNA functional classifications

Classification of Individual Consumption According to Purpose (COICOP)

Relevant categories

Division 04 Housing, water, electricity, gas and other fuels

04.4 Water supply and miscellaneous services related to dwellings

04.4.1 Water supply

Includes: associated expenditure such as hire of meters, reading of meters, standing charges etc.

Excludes: drinking water sold in bottles or containers (01.2.2); hot water or steam purchased from district heating plants (04.5.5).

04.4.2 Refuse collection

Refuse collection and disposal.

04.4.3 Sewage collection

Sewage collection and disposal.

04.4.4 Other

Division 13 Individual consumption expenditure of non-profit institutions serving households (NPISHs)

13.6.3 Environmental protection

Corresponds to COPNI headings 08.1.0 and 08.2.0. See below.

Classification of the Purposes of Non-Profit Institutions Serving Households (COPNI)

Relevant categories

Division 08. Environmental protection

08.1.0 Environmental protection services

This class covers the following NPISHs:

– Organisations set up to prevent or remedy damage to the environment.

– Associations that seek to protect wild animals or preserve particular species of animals, birds, fish, insects etc.

– Organisations that seek to preserve forests, wet-lands and areas of natural beauty.

Excludes: political parties mainly concerned with environment issues (07.1.0); associations that seek to prevent cruelty to domesticated animals (09.1.0).

08.2.0 R&D environmental protection

This class covers the following NPISHs:

– Organisations that undertake applied research and experimental development on subjects related to environment protection and trust funds and charitable organisations set up to finance such activities.

Classification of the Functions of Government (COFOG)

Relevant categories

Division 04 Economic affairs

04.2 Agriculture, forestry, fishing and hunting

04.2.1 Agriculture

– Administration of agricultural affairs and services; conservation, reclamation or expansion of arable land; agrarian reform and land settlement; supervision and regulation of the agricultural industry.

– Construction or operation of flood control, irrigation and drainage systems, including grants, loans or subsidies for such works.

– Operation or support of programmes or schemes to stabilize or improve farm prices and farm incomes; operation or support of extension services or veterinary services to farmers, pest control services, crop inspection services and crop grading services.

– Production and dissemination of general information, technical documentation and statistics on agricultural affairs and services.

– Compensation, grants, loans or subsidies to farmers in connection with agricultural activities, including payments for restricting or encouraging output of a particular crop or for allowing land to remain uncultivated.

Excludes: multi-purpose development projects (04.7.4).

04.2.2 Forestry

– Administration of forestry affairs and services; conservation, extension and rationalized exploitation of forest reserves; supervision and regulation of forest operations and issuance of tree-felling licences.

– Operation or support of reforestation work, pest and disease control, forest fire-fighting and fire prevention services and extension services to forest operators.

– Production and dissemination of general information, technical documentation and statistics on forestry affairs and services.

– Grants, loans or subsidies to support commercial forest activities.

Includes: forest crops in addition to timber.

04.2.3 Fishing and hunting

This class covers both commercial fishing and hunting and fishing and hunting for sport. The fishing and hunting affairs and services listed below refer to activities that take place outside natural parks and reserves.

– Administration of fishing and hunting affairs and services; protection, propagation and rationalized exploitation of fish and wildlife stocks; supervision and regulation of fresh-water fishing, coastal fishing, ocean fishing, fish farming, wildlife hunting and issuance of fishing and hunting licences.

– Operation or support of fish hatcheries, extension services, stocking or culling activities etc.

– Production and dissemination of general information, technical documentation and statistics on fishing and hunting affairs and services.

– Grants, loans or subsidies to support commercial fishing and hunting activities, including the construction or operation of fish hatcheries.

Excludes: control of offshore and ocean fishing (03.1.0); administration, operation or support of natural parks and reserves (05.4.0).

04.3 Fuel and energy

04.3.1 Coal and other solid mineral fuels

This class covers coal of all grades, lignite and peat irrespective of the method used in their extraction or beneficiation and the conversion of these fuels to other forms such as coke or gas.

– Administration of solid mineral fuel affairs and services; conservation, discovery, development and rationalized exploitation of solid mineral fuel resources; supervision and regulation of the extraction, processing, distribution and use of solid mineral fuels.

– Production and dissemination of general information, technical documentation and statistics on solid mineral fuel affairs and services.

– Grants, loans or subsidies to support the solid mineral fuel industry and the coke, briquette or manufactured gas industries.

Excludes: solid mineral fuel transportation affairs (classified to the appropriate class of group 04.5).

04.3.2 Petroleum and natural gas

This class covers natural gas, liquefied petroleum gases and refinery gases, oil from wells or other sources such as shale or tar-sands and the distribution of town gas regardless of its composition.

- Administration of petroleum and natural gas affairs and services; conservation, discovery, development and rationalized exploitation of petroleum and natural gas resources; supervision and regulation of the extraction, processing, distribution and use of petroleum and natural gas.
- Production and dissemination of general information, technical documentation and statistics on petroleum and natural gas affairs and services.
- Grants, loans or subsidies to support the petroleum extraction industry and the industry refining crude petroleum and related liquid and gaseous products.

Excludes: petroleum or gas transportation affairs (classified to the appropriate class of group 04.5).

04.3.3 Nuclear fuel

- Administration of nuclear fuel affairs and services; conservation, discovery, development and rationalized exploitation of nuclear material resources; supervision and regulation of the extraction and processing of nuclear fuel materials and of the manufacture, distribution and use of nuclear fuel elements.
- Production and dissemination of general information, technical documentation and statistics on nuclear fuel affairs and services.
- Grants, loans or subsidies to support the nuclear materials mining industry and the industries processing such materials.

Excludes: nuclear fuel transportation affairs (classified to the appropriate class of group 04.5); disposal of radioactive wastes (05.1.0).

04.3.4 Other fuels

- Administration of affairs and services involving fuels such as alcohol, wood and wood wastes, bagasse and other non-commercial fuels.
- Production and dissemination of general information, technical documentation and statistics on availability, production and utilization of such fuels.
- Grants, loans or subsidies to promote the use of such fuels for the production of energy.

Excludes: forest management (04.2.2); wind and solar heat (04.3.5) or (04.3.6); geothermal resources (04.3.6).

04.3.5 Electricity

This class covers both traditional sources of electricity such as thermal or hydro supplies and newer sources such as wind or solar heat.

- Administration of electricity affairs and services; conservation, development and rationalized exploitation of electricity supplies; supervision and regulation of the generation, transmission and distribution of electricity.
- Construction or operation of non-enterprise-type electricity supply systems.
- Production and dissemination of general information, technical documentation and statistics on electricity affairs and services.
- Grants, loans or subsidies to support the electricity supply industry, including such outlays for the construction of dams and other works designed chiefly to provide electricity.

Excludes: non-electric energy produced by wind or solar heat (04.3.6).

04.3.6 Non-electric energy

- Administration of non-electric energy affairs and services that chiefly concern the production, distribution and utilization of heat in the form of steam, hot water or hot air.
- Construction or operation of non-enterprise-type systems supplying non-electric energy.
- Production and dissemination of general information, technical documentation and statistics on availability, production and utilization of non-electric energy.
- Grants, loans or subsidies to promote the use of non-electric energy.

Includes: geothermal resources; non-electric energy produced by wind or solar heat.

04.4 Mining, manufacturing and construction

04.4.1 Mining of mineral resources other than mineral fuels

This class covers metal-bearing minerals, sand, clay, stone, chemical and fertilizer minerals, salt, gemstones, asbestos, gypsum etc.

– Administration of mining and mineral resource affairs and services; conservation, discovery, development and rationalized exploitation of mineral resources; supervision and regulation of prospecting, mining, marketing and other aspects of mineral production.

– Production and dissemination of general information, technical documentation and statistics on mining and mineral resource affairs and services.

– Grants, loans or subsidies to support commercial mining activities.

Includes: issuance of licences and leases, regulation of production rates, inspection of mines for conformity to safety regulations etc.

Excludes: coal and other solid fuels (04.3.1), petroleum and natural gas (04.3.2) and nuclear fuel materials (04.3.3).

04.4.2 Manufacturing

– Administration of manufacturing affairs and services; development, expansion or improvement of manufacturing; supervision and regulation of the establishment and operation of manufacturing plants; liaison with manufacturers' associations and other organizations interested in manufacturing affairs and services.

– Production and dissemination of general information, technical documentation and statistics on manufacturing activities and manufactured products.

– Grants, loans or subsidies to support manufacturing enterprises.

Includes: inspection of manufacturing premises for conformity with safety regulations, protection of consumers against dangerous products etc.

Excludes: affairs and services concerning the coal processing industry (04.3.1), the petroleum refinery industry (04.3.2) or the nuclear fuel industry (04.3.3).

04.4.3 Construction

– Administration of construction affairs and services; supervision of the construction industry; development and regulation of construction standards.

– Production and dissemination of general information, technical documentation and statistics on construction affairs and services.

Includes: issuance of certificates permitting occupancy, inspection of construction sites for conformity with safety regulations etc.

Excludes: grants, loans and subsidies for the construction of housing, industrial buildings, streets, public utilities, cultural facilities etc. (classified according to function); development and regulation of housing standards (06.1.0).

Division 05. Environmental protection

The breakdown of environment protection is based upon the Classification of Environmental Protection Activities and Expenditure (CEPA) as contained in annex V.

05.1 Waste management

Corresponds to CEPA heading 3.

05.2 Wastewater management

Corresponds to CEPA heading 2.

05.3 Pollution abatement

Corresponds to CEPA headings 1, 4, 5 and 7.

05.4 Protection of biodiversity and landscape

Corresponds to CEPA heading 6.

05.5 R&D environmental protection

Corresponds to CEPA heading 8.

05.6 Other

Corresponds to CEPA heading 9.

Division 06. Housing and community amenities

06.3 Water supply

– Administration of water supply affairs; assessment of future needs and determination of availability in terms of such assessment; supervision and regulation of all facets of potable water supply including water purity, price and quantity controls.

– Construction or operation of non-enterprise-type of water supply systems.

– Production and dissemination of general information, technical documentation and statistics on water supply affairs and services.

– Grants, loans or subsidies to support the operation, construction, maintenance or upgrading of water supply systems.

Excludes: irrigation systems (04.2.1); multi-purpose projects (04.7.4); collection and treatment of waste water (05.2.0).

Classification of the Outlays of Producers According to Purpose (COPP)

Relevant categories

Division 03 Outlays on environmental protection

The breakdown of environment protection is based upon the Classification of Environmental Protection Activities and Expenditure (CEPA) as contained in annex V.

Excludes: outlays for measures intended to improve the health, comfort or safety of employees (05); R&D (02).

03.1 Outlays on protection of ambient air and climate

Corresponds to CEPA heading 1.

03.2 Outlays on wastewater management

Corresponds to CEPA heading 2.

03.3 Outlays on waste management

Corresponds to CEPA heading 3.

03.4 Outlays on protection of soil and groundwater

Corresponds to CEPA heading 4.

03.5 Outlays on noise and vibration abatement

Corresponds to CEPA heading 5.

03.6 Outlays on protection of biodiversity and landscape

Corresponds to CEPA heading 6.

03.7.0 Outlays on environmental protection n.e.c.

Corresponds to CEPA headings 7 and 9.

Annex VII
Useful categories in activity classifications

Introduction

The purpose of the present annex is to give an indication of which activity classifications are likely to be most often used in environmental accounting. This first list given corresponds to the International Standard Industrial Classification of All Economic Activities (ISIC) as the international standard. The corresponding headings for both the Statistical Classification of Economic Activities in the European Community (NACE), the official classification of economic activities in the European Union, and the North American Industry Classification System (NAICS), the classification used by the North America Free Trade Area, are also presented.

ISIC categories that identify environmental protection activities

ISIC Rev. 3.1 division or class	Description
23	*Manufacture of coke, refined petroleum products and nuclear fuel*
2330 (part of)	Processing of nuclear fuel
37	*Recycling*
41[a]	*Collection, purification and distribution of water*
51	*Wholesale trade and commission trade, except of motor vehicles and motorcycles*
5149 (part of)	Wholesale of other intermediate products, waste and scrap
73 (part of)	*Research and development*
74	*Other business activities*
7421 (part of)	Architectural and engineering activities and related technical consultancy
7422 (part of)	Technical testing and analysis
75	*Public administration and defence; compulsory social security*
7512 (part of)	Regulation of the activities of agencies that provide health care, education, cultural services and other social services, excluding social security
90	*Sewage and refuse disposal, sanitation and similar activities*
91	*Activities of membership organizations n.e.c.*
9199 (part of)	Activities of other membership organizations n.e.c.
92	*Recreational, cultural and sporting activities*
9233 (part of)	Botanical and zoological gardens and nature reserves activities

Note: This list is not exhaustive. Environmental protection activities may also be part of other ISIC divisions and classes. Also, please note that not all output of these activities is environmental protection output.

[a] Part of resource management.

NACE, Rev. 1.1[a] categories that identify environmental protection activities

NACE, Rev. 1.1 division or classes	Description	ISIC Rev 3.1
23	Manufacture of coke, refined petroleum products and nuclear fuel	23
23.30 (part of)	Processing of nuclear fuel	2330 (part of)
37	Recycling	37
37.10	Recycling of metal waste and scrap	3710
37.20	Recycling of non-metal waste and scrap	3720
41[b]	Collection, purification and distribution of water	41[b]
41.00[b]	Collection, purification and distribution of water	4100[b]
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles	51
51.57	Wholesale of waste and scrap	5149 (part of)
74	Other business activities	74
74.20 (part of)	Architectural and engineering activities and related technical consultancy	7421 (part of)
74.30 (part of)	Technical testing and analysis	7422 (part of)
75	Public administration and defence; compulsory social security	75
75.12 (part of)	Regulation of the activities of agencies that provide health care, education, cultural services and other social services, excluding social security	7512 (part of)
90	Sewage and refuse disposal, sanitation and similar activities	90
90.01	Collection and treatment of sewage	9000 (part of)
90.02	Collection and treatment of other waste	9000 (part of)
90.03	Sanitation, remediation and similar activities	9000 (part of)
91	Activities of membership organizations n.e.c.	91
91.33 (part of)	Activities of other membership organizations n.e.c.	9199 (part of)
92	Recreational, cultural and sporting activities	92
92.53 (part of)	Botanical and zoological gardens and nature reserves activities	9233 (part of)

Note: This list is not exhaustive. Environmental protection activities may also be found in other NACE classes. Not all output of the activities listed is environmental protection output.

[a] NACE, Rev.1.1, replaced NACE, Rev.1, from statistical year 2003 onward.

[b] Part of resource management.

Environmental activities in the North American Industry Classification System (NAICS)[a]

Sector 22 Utilities

Group 2213 Water, sewage and other systems[b]

Industry 22131 Water supply and irrigation systems[b,c]

Industry 22132 Sewage treatment facilities[b]

Industry 22133 Steam and air-conditioning supply[b,c]

Sector 23 Construction

Group 2371 Utility system construction

Industry 23711 Water and sewer line and related structures construction[d]

Sector 54 Professional, scientific, and technical services

Group 5416 Management, scientific, and technical consulting services

Industry 54162 Environmental consulting services

Sector 56 Administrative and support and waste management and remediation services

Subsector 562 Waste management and remediation services

Group 5621 Waste collection[b]

Group 5622 Waste treatment and disposal[b]

Group 5629 Remediation and other waste management services[b]

Sector 71 Arts, entertainment, and recreation

Subsector 712 Museums, historical sites, and similar institutions

Industry 71219 Nature parks and other similar institutions

Sector 81 Other services (except public administration)

Group 8133 Social advocacy organizations

Industry 813312 Environment, conservation and wildlife organizations[e]

Sector 92 Public administration

Subsector 924 Administration of environmental quality programmes[e]

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[a] NAICS provides common industry definitions for Canada, Mexico and the United States of America.

[b] United States of America and Canada only.

[c] Part of resource management.

[d] Some part of this activity relates to resource management.

[e] United States of America only.

Annex VIII
Classification of the environment industry

A. POLLUTION MANAGEMENT group

Production of equipment and specific materials for:

1. Air pollution control.
2. Wastewater management.
3. Solid waste management:
   - 3.1 Hazardous waste collection, treatment and disposal;
   - 3.2 Waste collection, treatment and disposal;
   - 3.3 Waste recovery and recycling (excludes manufacture of new materials or products from waste and scrap).
4. Remediation and clean-up of soil, surface water and groundwater.
5. Noise and vibration abatement.
6. Environmental monitoring, analysis and assessment.
7. Other.

Provision of services for:

8. Air pollution control.
9. Wastewater management.
10. Solid waste management:
    - 10.1 Hazardous waste collection, treatment and disposal;
    - 10.2 Waste collection, treatment and disposal;
    - 10.3 Waste recovery and recycling (excludes manufacture of new materials or products from waste and scrap).
11. Remediation and clean-up of soil, surface water and groundwater.
12. Noise and vibration abatement.
13. Environmental R&D.
14. Environmental contracting and engineering.
15. Analytical services, data collection, analysis and assessment.
16. Education, training, information.
17. Other.

Construction and installation for:

18. Air pollution control.
19. Wastewater management.
20. Solid waste management:
    - 20.1 Hazardous waste collection, treatment and disposal;
    - 20.2 Waste collection, treatment and disposal;
    - 20.3 Waste recovery and recycling (excludes manufacture of new materials or products from waste and scrap).

21. Remediation and clean-up of soil, surface water and groundwater.
22. Noise and vibration abatement.
23. Environmental monitoring, analysis and assessment.
24. Other.

B. CLEANER TECHNOLOGIES AND PRODUCTS group

Production of equipment, technology, specific materials or services for:

1. Cleaner/resource-efficient technologies and processes.
2. Cleaner/resource-efficient products.

C. RESOURCE MANAGEMENT group

Note: For this group, activities aimed at the production of environmental goods and services and related construction are grouped together for convenience. However, it is suggested that, wherever possible, information on these items be separately collected and presented.

Production of equipment, technology and specific materials, provision of services, and construction and installation for:

1. Indoor air pollution control.
2. Water supply.
3. Recycled materials (manufacture of new materials or products from waste or scrap, separately identified as recycled).
4. Renewable energy plant.
5. Heat/energy saving and management.
6. Sustainable agriculture and fisheries.
7. Sustainable forestry.
8. Natural risk management.
9. Eco-tourism.
10. Other (for example, nature conservation, habitats and biodiversity).

Annex IX
Relationship between the SEEA and the 1993 SNA

Introduction

The SEEA is envisaged as a satellite account of the 1993 SNA. This means that, while some flexibility in the SNA may be introduced, it is important to be clear about when such flexibility has been deliberately introduced and why. The purpose of the present annex is thus to explain how the accounting system of the SEEA is related to that of the SNA. It explains the relationships between concepts and definitions, accounting rules and methods of valuation in the two systems. It has been written under the assumption that the reader has detailed knowledge of the SNA.

For each of the chapters III-X, the material is reviewed under up to four sub-headings. The first, ***Adding supplementary information***, describes the extensions to the SNA introduced by the SEEA. The second sub-heading, ***Clarifying SNA definitions***, highlights a number of cases where it was necessary to seek more precise definitions of SNA concepts in order for these to be operational in the context of environmental accounting. It is suggested that these clarifications be considered for incorporation into the SNA itself, since there is no intention of changing the system, simply of increasing what is believed to be the precision intended therein. The third sub-heading, ***Expanding the SNA exposition***, refers to sections where the text in this Handbook goes into rather greater detail than the text of the SNA with respect to explaining how particular accounts are to be elaborated. In this case also, no change to the underlying system in intended. The last sub-heading, ***Changing the accounting entries***, refers to the cases where deliberate changes to the SNA accounts are suggested, as options, within the context of a satellite account. Not all section sub-headings appear under each chapter heading. When a sub-heading is absent, this means that there is nothing in the chapter relevant to the material under this sub-heading. In particular, the fourth sub-heading appears seldom.

Chapter III: Physical flow accounts

Adding supplementary information

Chapter III shows how a supply and use framework, similar to that in the SNA, can be established measured in physical terms. Fundamental to this are four basic ***concepts***, namely, the concept of products, the concept of natural resources, the concept of ecosystem inputs and the concept of residuals. The product concept is used in precisely the same way as in the SNA. None of the other three concepts have explicit prices. The means of determining implicit prices for natural resources are described in chapter VII and possible valuations that could be attributed to residuals are discussed in chapter IX. There is no discussion of valuing ecosystem inputs (typically, the air and water necessary to all life forms).

A number of ***classifications*** have to be used in conjunction with the four basic concepts. Products are classified according to the International Standard Industrial Classification of All Economic Activities (ISIC) and the Central Product Classification (CPC) as in the SNA. Particularly relevant headings of the CPC are given in annex III. Relevant headings of industrial classifications (ISIC, the Statistical Classification of Economic Activities in the European Community (NACE) and the North American Industry Classification System (NAICS)) are provided in annex VII. Annex II contains a classification for use with natural resources and ecosystem inputs. A classification of residuals is provided in annex IV.

The ***accounts*** described in chapter III are based on the normal supply and use identity, and a composite supply and use table is developed. Columns for industries and final demand include products, natural resources and ecosystem inputs; rows for products include products and residuals.

Chapter IV: Hybrid flow accounts

Adding supplementary information

This chapter takes the supply and use ***account*** from chapter III and superimposes the SNA supply and use table in monetary terms on that part of the physical table relating to products (hence the importance of using precisely the same definitions and classifications for products).

From this, it is possible to derive a set of prices for products, but the difference in ***concept*** between physical volumes and national accounts volumes where quality changes are taken into account is emphasized here and later on in the Handbook.

Expanding the SNA exposition

The chapter explains how a supply and use table can be transformed into input-output format and discusses how the input output format can be used to track direct and indirect effects of particular final uses through the system.

Chapter V: Accounting for economic activities and products related to the environment

Adding supplementary information

This chapter identifies four relevant activities associated with environmental protection and resource management: environmental protection activities, natural resource management and exploitation activities, environmentally beneficial activities, and minimization of natural hazards. So far, most work has been done in respect of the first category and a new ***classification*** of environmental protection activities (CEPA) is introduced and reproduced in annex V. This classification has been adopted as an international standard. The functional classifications for final and intermediate consumption used by the SNA (the Classification of the Functions of Government (COFOG), the Classification of Individual Consumption According to Purpose (COICOP) and the Classification of the Outlays of Producers According to Purpose (COPP)) have been updated since the SNA was published in 1993 and, in the updating, the proposals for CEPA were taken into account to ensure consistency among these classifications. The relevant headings from COFOG, COICOP and COPP are given in annex VI.

Expanding the SNA exposition

Once the CEPA has been introduced, the chapter goes on to describe how accounts can be established to measure the level of environmental protection activity. This represents an elaboration of proposals made in chapter XXI of the SNA. One aspect is the identification of those activities producing goods and services characteristic of environmental protection. This group of activities is referred to as the "environment industry" and is considered in annex VIII.

Changing the accounting entries

In connection with elaborating the environmental protection accounts, it is desirable to record some ancillary activity separately. This alters the level of output in an industry but not the level of value added, since intermediate consumption increases correspondingly. This process is described in chapter XXI of the SNA also.

Chapter VI: Accounting for other environmentally related transactions

Clarifying SNA definitions

This chapter discusses how environmentally related taxes, property income and property rights can be identified within the SNA. The distinction between payment of a tax, the payment of rent for the use of a non-produced asset and payment for a service is reviewed. A set of taxes with an environmental base is established.

Although the SNA mentions only rent on land and rent on subsoil deposits, this Handbook states that, conceptually, rent may be payable on other environmental resources and, when this occurs, the category of rent should be further disaggregated to show this. One example involves the payment of licences for commercial fishing activities. The SNA guidance that licences for hunting, shooting and fishing be treated as taxes on income applies only in the case of licences paid by individuals in respect of recreational activities. (It is arguable that from an environmental point of view these too could be regarded as rent, but there would be no impact on overall economic aggregates and the amounts involved are extremely small relative to total economic activity.)

The acquisition of property rights through the purchase (or acquisition by other means) of licences bestowing the right to use an asset for an extended period of time should be regarded as the acquisition of an intangible non-produced asset. Fishing licences and emissions permits are particularly relevant for environmental accounting.

The chapter also discusses costs incurred when fixed assets are decommissioned and suggests that these costs be taken into account via the consumption of fixed capital during the life of the asset, so that the cumulative value of consumption of fixed capital over the life of the asset (excluding the effects of inflation) will cover both the initial cost and any disposal costs. This is particularly relevant for the disposal of oil rigs and landfill sites.

Expenditure to prevent leaching from landfill sites after their closure and soil decontamination should be recorded as part of land improvements and recorded as fixed capital formation in the SNA, and not just in the SEEA.

Expanding the SNA exposition

The chapter explains how chapter XVIII of the SNA expands an input-output table to the format of a matrix including all the current and capital flow transactions. It goes on to discuss how extra cross-classifications can be introduced (for example, household consumption by product and by function). The hybrid version of such a table contains the physical data for natural resource and ecosystem inputs and residual outputs and shows how more non-monetary data (for example, labour-market information) can be incorporated.

Chapter VII: Asset accounts and the valuation of natural resource stocks

Adding supplementary information

Chapter VII presents a ***classification*** of environmental assets that is broader than that of the SNA by introducing assets that are not recognized as "economic assets" in the SNA. The details of this classification are given in annex I. An example of such an asset may be land that is so remote and so inhospitable that it has no commercial value but still provides environmental services.

Clarifying SNA definitions

Even within the SNA context, there have been problems with respect to determining when a biological resource such as a forest should be treated as cultivated and when as non-cultivated. As a result of discussions, the SEEA recommends that the SNA definition of cultivated assets be qualified by having the phrase given in bold italics in the extract below replace the word "that". The definition of cultivated assets is brought into line with that of non-cultivated asset where such a phrase exists. Hence, cultivated assets cover livestock for breeding, dairy, draught etc. and vineyards, orchards and other plantations of trees yielding repeat products ***whose natural growth and regeneration*** are under the direct control, responsibility and management of institutional units.

Further, it should be understood that the processes involved should constitute production in the SNA sense and not represent a purely legislative process. The activities concerned are likely to fall within ISIC tabulation category A or B.

Expanding the SNA exposition

The SEEA makes extensive use of the asset account which shows how, for a given asset, the opening and closing balance sheets can be reconciled by accounting for all the changes that take place in the year. While the philosophy is well understood by national accountants, the asset account itself is little known or implemented (although it is described in the annex to chapt. II of the 1993 SNA). Chapter VII of this Handbook shows how the asset accounts for different classes of assets can be integrated with the flows matrix described in chapter VI by including a cross-classification of assets by type of asset and owner.

There is extensive discussion in chapter VII on the capital service approach to the valuation of assets, as described in two manuals published by OECD on measuring capital and productivity (Organisation for Economic Cooperation and Development (OECD), 2001a; 2001b). This approach helps establish parallels between the valuation of fixed capital and the valuation of natural assets and between the decline in value of fixed assets (consumption of fixed capital) and a value that can be ascribed to the decline in value (depletion) of natural resources.

Changing the accounting entries

Land appears as a non-produced asset in the SNA and is subdivided into land under buildings, land under cultivation, recreational land and other land. It is recognized that recreational land has characteristics that could lead to a potential classification into other categories. Where this is so, the SNA recommends choosing the category that represents the greater part of the value. This solution is not satisfactory from the SEEA perspective. It is recommended that recreational land be treated as a secondary characteristic shown as an "of which" category to permit reconciliation with the SNA.

The SNA recommends that the value of subsoil deposits recorded in the balance sheet should refer only to proven reserves. In some countries, figures for proven reserves are not available separately from those for probable reserves. In others, even where a separation is possible, it is felt that it would be more realistic to include probable reserves also, even in the SNA balance sheet. This Handbook therefore recommends that reserves of all categories should be included in the SEEA balance sheet and that probable reserves should be included in the SNA balance sheet, at least as a memorandum item.

Growing concern about dwindling fish stocks has led to the creation of country quotas in respect of fish in the ocean beyond national economic zones. This Handbook recommends that the value of the fish represented by these allocated quotas should be included in the SEEA balance sheet and at least as a memorandum item in the SNA balance sheet. (The quotas in question are allocated by international agreement to a country rather than to individual fishing concerns. They are thus rather different from the fishing licences described above, though clearly such fishing licences issued by a national Government could relate to fish to be caught under an international quota.)

Chapter VIII: Specific resource accounts

The points raised under this heading actually include points relevant to specific resources in chapters VII and X as well as those made in Chapter VIII.

Mineral and energy resources

As noted above, the SEEA recommends that a measure of subsoil deposits that is more inclusive than, simply, proven reserves be recorded.

There is quite an extensive discussion in both chapters VII and VIII on the interpretation of the treatment of mineral exploration. Although the SNA recommends valuation "at cost", this should not be taken to necessarily exclude an element of net operating surplus.

When the value of subsoil deposits is calculated using net present value techniques applied to resource rent, the implications are that the higher the value of mineral exploration, the lower the value of the subsoil deposit. This means that two deposits of identical characteristics could have different values if one is found with relatively little effort and the other only after extensive and expensive exploration.

The SNA recommends that the value of the resource should appear in the balance sheet of the owner. Alternative possible forms of recording are explored in the SEEA.

Water resources

At present, most water circulating within an economy does so without a direct cost. This is set to change in future as water becomes increasingly scarce and more explicit charging for its use is made. This may necessitate changes in the SEEA guidelines given in this Handbook as water is treated less as an ecosystem input and more as an economic product. In addition, changes may be necessary for the coverage of water as an asset in the SNA. A further consequence is that water that has already been used may acquire a value and become a product like some other items that are candidates for recycling.

Forests

Chapter VIII examines how separate elements of forests - the standing timber, the land under the trees, forest products such as berries and game, and the amenity value of the forest - may be valued individually. By implication, the SNA recommends that the value to be placed on a forest in the SNA accounts should include all these elements, though it is not certain that this is always followed in practice.

Aquatic resources

From the point of view of management of fish stocks within a country's EEZ, it is desirable to have data available on total catches from the EEZ as well as on total catches by residents in the EEZ and by residents worldwide. This information should be collected, if at all possible, in terms of both physical quantities and monetary values.

Chapter IX: Valuation techniques for measuring degradation

Expanding the SNA exposition

Chapter IX is concerned only with the description of pricing techniques. It describes prices consistent with the SNA, including some of the newer techniques being adopted, such as hedonic pricing. It also discusses some pricing techniques that are not consistent with SNA valuation because of the inclusion of an element of consumer surplus.

Chapter X: Making environmental adjustments to the flow accounts

Changing the accounting entries

Chapter X discusses three areas in which changes to the SNA flow accounts might be introduced to derive macroeconomic aggregates that differ from the conventional ones. It is made clear that these are adjustments suggested only within the context of a satellite account. In each case, a number of alternatives are presented, including the option of not making an adjustment. The three areas are those of depletion, defensive expenditure and degradation. To a considerable extent, the options applicable in each of these areas can be chosen independently of those in the other areas.

In the section on ***depletion***, various possibilities for incorporating an element into the flow accounts matching the decline in the value of a natural resource are discussed. Such an item could be introduced in either the generation of income account or, possibly, the distribution of primary income account. The effect is to reduce subsequent balancing items, including the main macroeconomic aggregates, on a "depletion-adjusted" basis where both the consumption of fixed capital and the consumption of natural capital have been deducted from the gross balancing items.

In the section on ***defensive expenditure***, an option is presented whereby environmental protection expenditure can be shown both as a form of capital formation and, at the same time, as consumption of fixed capital. This increases the value of GDP by the amount of environmental protection expenditure currently included in intermediate consumption (including as an ancillary activity) and decreases NDP by the amount of expenditure that takes the form of final consumption. This provides consistent treatment regardless of whether environmental protection is undertaken by a producing unit or for final consumption. The gap between GDP and NDP is widened by the whole of current environmental protection expenditure.

The section on ***degradation*** includes three main options. The first is to place a valuation on the damage done by the emission of residuals and to deduct this from income to obtain a total called "damage-adjusted" national income. It is noted that this is a partial implementation of a welfare approach to measurement of income and is strictly inconsistent with SNA aggregates because a deduction is made for reductions in welfare but no addition is made for the fact that welfare is generally supposed to exceed income.

The second approach, which appears in the 1993 SEEA, is called the maintenance cost approach and leads to "environmentally adjusted" aggregates. It presupposes that extra environmental protection expenditure will be undertaken either to eliminate residual generation or to reduce this to a pre-specified level. It is inconsistent with the SNA accounts in that no adjustments are made for the purposes of explaining the source of the imputed extra expenditure. It is also inconsistent with observed (and desired) economic behaviour which postulates that, if faced with explicit costs associated with protecting the environment, producers and consumers would adjust their behaviour as well as their spending patterns to achieve this.

The third approach, which is a modelling and not an accounting approach, leads to “greened economy” aggregates. It supposes that residual emission is avoided or reduced by a combination of changes in production and consumption patterns. The underlying accounting is perfectly consistent with the SNA but the resulting levels of activity and of macroeconomic aggregates are hypothetical and not observed.

Glossary

The definitions in this glossary are based as closely as possible on the actual wording used in SEEA-2003. However, in some cases it was not possible to find definitions of the terms in the SEEA-2003, and it has been necessary to develop definitions based on the text. The aim of the glossary has been to have each definition "stand alone" to the greatest extent possible. The only way this could be achieved in a large number of cases was to add to or change the actual wording used in the SEEA-2003.

For ease of reference SNA definitions which are repeatedly used in the SEEA-2003 are included in this glossary. They are directly taken from the SNA glossary available from http://unstats.un.org/unsd/SNA1993/glossary.asp and are referenced indicating 'SNA' before the number of the paragraphs. References in [ ] are not as significant as references without them. 'AN' refers to the SNA 1993 classification of non-financial assets.

For ease of reference 'FAO' refers to definitions taken from the FAO online glossary available from http://www.fao.org/fi/glossary; 'TBFRA' refers to definitions taken from the glossary of the UNECE/FAO Temperate and Boreal Forest Resources Assessment 2000, available from http://www.unece.org/trade/timber/fra/definit.htm; 'EA' refers to the SEEA asset classification of environmental assets, Annex 1 of this handbook.

Often the brief definition contained in the glossary gives only a general idea of the item concerned and so it is necessary to put it into context. To make it easier for the reader, each definition shows the paragraph of SEEA-2003 from which the definition has been derived, as well as other references that may be useful in determining a more precise meaning of each term.

Abatement costs: An approach within the maintenance cost. It includes expenditures which reduce the direct pressures on natural assets (for example from air emissions or waste disposal). (SEEA-2003 para. 9.37).

Accumulation accounts: Flow accounts that record the acquisition and disposal of financial and non-financial assets and liabilities by institutional units through transactions or as a result of other events. (1993 SNA para. 1.9 [2.93, 10.1]).

Acidifying potential: The aggregate measure of the acidifying potential of some substances, calculated through the conversion factor of sulphur oxides and nitrogen and ammonia into acidification equivalents (H+ ion). (SEEA-2003 para. 3.28).

Acquisitions less disposals of non produced non financial assets: The total value of the non produced non financial assets acquired during the accounting period less the total value of the assets disposed of. Acquisitions less disposals of land, other tangible non produced assets and intangible non produced assets are distinguished. (1993 SNA para. 10.120).

Actual final consumption of general government: The value of the collective (as opposed to individual) consumption services provided to the community, or large sections of the community, by general government; it is derived from their final consumption expenditure by subtracting the value of social transfers in kind payable. (1993 SNA paras. 9.97, 9.3).

Actual final consumption of households: Value of the consumption goods and services acquired by households, whether by purchase in general, or by transfer from government units or NPISHs, and used by them for the satisfaction of their needs and wants; it is derived from their final consumption expenditure by adding the value of social transfers in kind receivable. (1993 SNA paras. 9.11, 9.3 [9.72, 9.96]).

Adapted products: Products which have been specifically modified to be more environmentally friendly and whose use is beneficial for environmental protection. These products are sometimes also called (environmentally) cleaner products. (SEEA-2003 para. 5.80).

Additions to the value of tangible non produced non financial assets: Acquisitions that lead to increase in the quantity, quality or productivity of land and other non- produced non financial tangible assets, or prevent their deterioration. They are treated as gross fixed capital formation. (1993 SNA para. 10.51).

Adjusted disposable income: Derived from the disposable income of an institutional unit or sector by adding the value of the social transfers in kind receivable by that unit or sector and by subtracting the value of the social transfers in kind payable by that unit or sector. (1993 SNA para. 8.24 [8.26]).

Agricultural land and associated surface water: Equivalent to the SNA category "land under cultivation" (AN.2112) except for the qualification on recreational land (see *recreational land*) and the exclusion of plantations (see *plantations*). The SEEA goes beyond the SNA in identifying specific sub-categories of agricultural land: cultivated land, pasture land and other agricultural land. (SEEA-2003 para. 7.64, EA. 22)

Amenity functions: A type of service functions, the other being survival functions, defined as those functions that improve the quality of life, for instance providing a pleasant landscape for leisure pursuits. (SEEA-2003 para. 1.23).

Ancillary activity: Supporting activity undertaken within an enterprise in order to create the conditions within which the principal or secondary activities can be carried out; ancillary activities generally produce services that are commonly found as inputs into almost any kind of productive activity and the value of an individual ancillary activity's output is likely to be small compared with the other activities of the enterprise (e.g. cleaning and maintenance of buildings).(1993 SNA paras. 5.9, 5.10 [15.16]).

Annual fellings: The average annual standing volume of all trees, living or dead, measured over bark (with no minimum diameter) that are felled during the reference period, including the volume of trees or parts of trees that are not removed from forested land, other wooded land and other felling sites. Annual fellings include silvicultural and pre-commercial thinnings and cleanings left in the forest, and natural losses not recovered. (SEEA-2003 para. 8.179; TBFRA).

Annual removals: The average annual volume of those fellings that are removed from forested land, other wooded land and other felling sites during the reference period, which include removals during the reference period of trees felled during an earlier period and removal of trees killed or damaged by natural causes (natural losses), e.g. fire, storms, insects and diseases. (SEEA-2003 para. 8.179; TBFRA).

Appropriation method: A method for estimating resource rent, in which resource rent is equated with the fees, taxes and royalties collected from the companies involved in the resource extraction. (SEEA-2003 para. 7.174).

Assets: See *economic assets* and *environmental assets*.

Avoidance costs: An approach within the maintenance cost approach. Expenditure for reducing emissions and more generally alleviating pressure on the environment. These costs fall into two categories: structural adjustment costs and abatement costs. See *structural adjustment costs* and *abatement costs*. (SEEA-2003 para. 9.35).

Balance sheet: Statement, drawn up at a particular point in time, of the values of assets owned by an institutional unit or sector and of the financial claims (i.e. liabilities) incurred by this unit or sector; for the economy as a whole, the balance sheet shows what is often referred to as "national wealth" - the sum of non-financial assets and net claims on the rest of the world. (1993 SNA paras. 13.1, 13.2 [1.11, 2.93, 10.1]).

Balancing item: An account is "closed" by introducing a balancing item defined residually as the difference between the two sides of the account; a balancing item typically encapsulates the net result of the activities covered by the account in question and is therefore an economic construct of considerable interest and analytical significance - for example, value added, disposable income, saving, net lending and net worth. (1993 SNA para. 1.3 [3.64]).

Base period: The period that provides the structural weights for an index. (1993 SNA para. 16.16).

Basic price: Amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any tax payable, and plus any subsidy receivable, on that unit as a consequence of its production or sale; it excludes any transport charges invoiced separately by the producer. (1993 SNA paras. 6.205, 15.28 [3.82]).

Bequest benefit: Derived from the continued existence of elements of the environment because they may one day provide benefits for those yet to be born. An example of these types of benefits is that derived from maintaining a rain forest to protect future sources of genetic material for drugs or hybrid agricultural crops. (SEEA-2003 para. 7.37).

Best available technology: State of the art processes, facilities or methods of operation, which indicates the practical suitability of a particular measure for limiting discharges. (SEEA-2003 para. 9.42).

Biological resources: Timber resources, crop and plant resources, aquatic resources, and animal resources other than aquatic that bring use benefits today or that may do so in the future. Each category of biological resource in the SEEA asset classification is subdivided into cultivated and non cultivated sub-categories. See *cultivated biological resources* and *non-cultivated biological resources*. (SEEA-2003 para. 7.53, EA.14).

Capital account: Records the values of the non-financial assets that are acquired, or disposed of, by resident institutional units by engaging in transactions. It shows the change in net worth due to saving and capital transfers or internal bookkeeping transactions linked to production (changes in inventories and consumption of fixed capital). (1993 SNA paras. 10.20, 1.9).

Capital approach to sustainable development: Sustainable development, from a capital standpoint, is development that ensures non-declining per capita national wealth by replacing or conserving the sources of that wealth, i.e. stocks of produced, human, social and natural capital. (SEEA-2003 para. 1.21).

Capital expenditure for environmental protection: Includes internal spending on gross capital formation for environmental protection such as all relevant outlays for machinery and equipment and their installation and repair that have been capitalized, as well as for the construction of non-residential facilities (contractors or own employees). For construction, all costs associated with demolition, planning and design (such as engineering and construction fees), any materials supplied to construction contractors for installation and any costs associated with the purchase of land that are neither amortized nor depreciated are included. (SEEA-2003 para. 5.98).

Capital services: The productive inputs, per period, that flow to production from a capital asset. The value of capital services is the quantity of services provided by the asset multiplied by the price of those services. (OECD, 2001a).

Capital stock – gross: Value of all fixed assets still in use at the actual or estimated current purchasers' prices for new assets of the same type, irrespective of the age of the assets. (1993 SNA para. 6.199).

Capital stock – net: The sum of the written-down values of all the fixed assets still in use is described as the net capital stock. (1993 SNA para. 6.199).

Capture fisheries: The sum (or range) of all activities to harvest a given fish resource. It may refer to the location (e.g. Morocco, Georges Bank), the target resource (e.g. hake), the technology used (e.g. trawl or beach seine), the social characteristics (e.g. artisanal, industrial), the purpose (e.g. commercial, subsistence, or recreational) as well as the season (e.g. winter). (SEEA-2003 para. 8.273; FAO).

Carbon dioxide equivalent: Conversion factor of greenhouse gases in term of warming potential relative to that of carbon dioxide. (SEEA-2003 para. 3.27).

Catastrophic losses: Recorded in the "other changes in the volume of assets account" unanticipated losses resulting from large scale, discrete, and recognisable events that may destroy assets within any of the categories of assets. (1993 SNA para. 12.35).

Catch: The total number (or weight) of fish caught by fishing operations. Catch should include all fish killed by the act of fishing, not just those landed. In environmental accounting the catch caught by resident operators constitutes production in the SUT regardless of where it's caught. Catches from national waters, regardless of the nationality of the operator, are recorded as catch in the asset accounts. (FAO).

Central government: Political authority that extends over the entire territory of the country. It has the authority to impose taxes on all resident and non-resident units engaged in economic activities within the country. (1993 SNA para. 4.118).

Central product classification (CPC): Classification based on the physical characteristics of goods or on the nature of the services rendered; each type of good or service distinguished in the CPC is defined in such a way that it is normally produced by only one activity as defined in ISIC. (1993 SNA para. 5.44).

Classification of environmental protection activities (CEPA 2000): The internationally agreed classification of environmental protection activities. It is a functional classification to classify activities, products, outlays and other transactions whose primary purpose is environmental protection, for purposes of environmental statistics and environmental accounts. Year of last revision is 2001 and subject to revision every 7 years. (SEEA-2003 para. 5.35, Annex 5).

Classification of individual consumption by purpose (COICOP): Classification used to identify the objectives of both individual consumption expenditure and actual individual consumption. (1993 SNA para. 18.7).

Classification of outlays of producers by purpose (COPP): Classification used to classify expenditures by producers (intermediate consumption, compensation of employees, etc) by purpose (e.g. outlays on repair and maintenance or outlays on sales promotion). (1993 SNA para. 18.13).

Classification of the functions of government (COFOG): Classification used to identify the socio-economic objectives of current transactions, capital outlays and acquisition of financial assets by general government and its sub sectors. (1993 SNA para. 18.9).

Classification of the purposes of non-profit institutions (COPNI): Classification used to identify the socio-economic objectives of current transactions, capital outlays and acquisition of financial assets by non-profit institutions serving households. (1993 SNA para. 18.12).

Collective consumption service: Service provided by general government simultaneously to all members of the community or to all members of a particular section of the community, such as all households living in a particular region. (1993 SNA para. 9.43).

Compensation of employees: Total remuneration, in cash or in kind, payable by enterprises to employees in return for work done by the latter during the accounting period. (1993 SNA para. 7.21 [7.31]).

Compliance criterion: One of four alternative methods criteria used to define environmental protection expenditures. The other three criteria are the pure purpose criterion, the extra cost criterion, and the net-cost criterion. The compliance criterion refers to expenditure undertaken with the main objective of protecting the environment but specifically in order to comply with environmental protection legislation, conventions and voluntary agreements. This can be further sub-divided to show those activities and transactions undertaken in order to comply with legislation only. (SEEA-2003 para. 5.30).

Conjoint analysis approaches: A stated preference valuation technique, that infers a value from the hypothetical choices or trade-offs that people make, without directly asking people to state their values in monetary terms. People are asked to state preference between one group of environmental services or characteristics at a given price or cost to the individual and another group of environmental characteristics at a different price or cost. (SEEA-2003 para. 9.102).

Connected products: Products that are used directly and solely for environmental protection purposes (e.g. septic tanks, filters, waste bags). (SEEA-2003 para. 5.83).

Constant prices: Obtained by directly factoring changes over time in the values of flows or stocks of goods and services into two components reflecting changes in the prices of the goods and services concerned and changes in their volumes, i.e. changes in "constant price terms". (1993 SNA para. 16.2).

Consumer durables: Durable goods acquired by households for final consumption (i.e. those that are not used by households as stores of value or by unincorporated enterprises owned by households for purposes of production); they may be used for purposes of consumption repeatedly or continuously over a period of a year or more. (1993 SNA para. 9.38).

Consumer surplus: Measures the difference between what a consumer is willing to pay for particular goods or services and the amount he/she actually is required to pay. (SEEA-2003 para. 9.99).

Consumption good or service: Product used (without further transformation in production) by households, NPISHs or government units for the direct satisfaction of individual needs or wants or the collective needs of members of the community. (1993 SNA para. 9.41).

Consumption of fixed capital: Represents the reduction in the value of the fixed assets used in production during the accounting period resulting from physical deterioration, normal obsolescence or normal accidental damage. (1993 SNA para. 10.27 [6.179, 10.118]).

Contingent valuation: A stated preference valuation technique, that presents hypothetical situations to a representative sample of the relevant population in order to elicit statements about how much they would be willing to pay for specific environmental services. (SEEA-2003 para. 9.92).

Cost-benefit analysis: Analysis that compares the values of all benefits from the action under consideration and the costs associated with it. (SEEA-2003 para. 9.9).

Critical capital: Equivalent of natural capital which is irreplaceable and essential for human survival. Such critical capital should be monitored separately in physical units. (SEEA-2003 para. 11.74).

Cultivated assets: Includes livestock for breeding (including fish and poultry), dairy, draught, etc. and vineyards, orchards and other plantations of trees yielding repeat products that are under the direct control, responsibility and management of institutional units. (1993 SNA, AN.1114, para. [10.83]).

Cultivated biological resources: They correspond to cultivated fixed assets and work in progress on cultivated assets in the SNA. The SEEA further clarifies the SNA definition: cultivated fixed assets are "livestock for breeding, dairy, draught, etc. and vineyards, orchards and other trees yielding repeat products whose natural growth and/or regeneration is under the direct control, responsibility and management of institutional units". Work in progress on cultivated assets consist of "livestock raised for products yielded only on slaughter, such as fowl and fish raised commercially, trees and other vegetation yielding once-only products on destruction and immature cultivated assets yielding repeat products". (SEEA-2003 para. 7.57).

Cultivated land: Land used for the growing of crops on a cyclical or permanent basis. Also included is the land that is normally cultivated but that has been allowed to go temporarily fallow. (SEEA-2003 para. 7.65).

Current accounts: Record the production of goods and services, the generation of incomes by production, the subsequent distribution and redistribution of incomes among institutional units, and the use of incomes for purposes of consumption or saving. (1993 SNA para. 1.5).

Current expenditure for environmental protection: Includes internal operational spending on environmental protection activities, for example, wages and salaries of people involved with the operation of pollution control equipment and environmental management, costs associated with the maintenance and repair of pollution control equipment, leasing payments for environmental equipment, and materials such as air filters and scrubbers. External expenditure such as waste disposal by specialists contractors, waste water treatment, regulatory charges to environmental agencies and so on are also treated as current expenditure whether made by enterprises, government or households. (SEEA-2003 para. 5.97).

Current transfers within general government: Consist of current transfers between different government units or different sub-sectors of general government. (1993 SNA para. 8.90).

Decommissioning cost: See *terminal costs*.

Degradation: Decrease in value of ecosystems due to human activities. (SEEA-2003 para. 10.142).

Depletion: Decrease in value of natural resource stocks due to extraction. (SEEA-2003 para. 7.168).

Depreciation: See *consumption of fixed capital*.

Direct material input (DMI): An indicator that measures the input of all materials of economic value and used in production and consumption activities. DMI equals domestic (used) extraction plus imports. (SEEA-2003 para. 3.199).

Direct material output (DMO): An indicator that measures the total quantity of direct material outputs leaving the economy after use either towards the environment or towards the rest of the world. DMO equals the sum of Domestic Processed Output (DPO) and exports. (SEEA-2003 para. 3.203).

Direct use benefits: Include the use of environmental assets as sources of materials, energy or space for input into human activities. (SEEA-2003 para. 7.36).

Discarded catch (dead or live): The total live weight of undersized, unsaleable or otherwise undesirable whole fish discarded at the time of capture or shortly afterwards. (SEEA-2003 Figure 8.4)

Discount rate: Rate used to discount future income to give an equivalent value in the present period. Expresses a time preference: the preference of an asset's owner for income today rather than in the future; and also the owner's attitude towards risk. See *net present value*. (SEEA-2003 para. 7.189).

Discoveries: Gross additions to the level of subsoil reserves due to the discovery of completely new reserves. In SEEA, not only additions to the stock of proven reserves but also additions to probable and possible reserves are recorded. (SEEA-2003 para. 7.104).

Disposable income: Derived from the balance of primary incomes of an institutional unit or sector by adding all current transfers, except social transfers in kind, receivable by that unit or sector and subtracting all current transfers, except social transfers in kind, payable by that unit or sector. (1993 SNA para. 8.11).

Distribution and use of income accounts: Consist of a set of articulated accounts showing how incomes are: (a) generated by production; (b) along with property income, distributed to institutional units with claims on the value added created by production; (c) redistributed among institutional units, mainly by government units through social security contributions and benefits and taxes; and (d) eventually used by households, government units or non-profit institutions serving households (NPISHs) for purposes of final consumption or saving. (1993 SNA para. 1.7).

Domestic material consumption (DMC): An indicator that measures the total amount of material directly used in an economy, excluding hidden flows. DMC equals Direct material input (DMI) minus exports. (SEEA-2003 para. 3.205).

Domestic processed output (DPO): An indicator that measures the total mass of materials which have been used in the national economy, before flowing into the environment. These flows occur at the processing, manufacturing, use, and final disposal stages of the economic production-consumption chain. Exported materials are excluded because their wastes occur in other countries. Included in DPO are emissions to air from commercial energy combustion and other industrial processes, industrial and household wastes deposited in landfills, material loads in waste water, materials dispersed into the environment as a result of product use (dissipative flows), and emissions from incineration plants. Material flows recycled in industry are not included in DPO. (SEEA-2003 para. 3.201).

Dose-response function: Measures the relationship between exposure to pollution as a cause and specific outcomes as an effect. A mathematical relationship is established which measures how much a certain amount of pollution impacts on production, capital, ecosystems, human health etc. (SEEA-2003 para. 9.58)

Dwellings: Buildings that are used entirely or primarily as residences, including any associated structures, such as garages, and all permanent fixtures customarily installed in residences; movable structures, such as caravans, used as principal residences of households are included. (1993 SNA, AN.1111).

Eco-efficiency profiles: Profiles that combine economic contribution and environmental burden by industry. The economic contribution is represented, for example, by the percentage each industry contributes to GDP or employment. The environmental burden is represented by the percentage each industry contributes to the emission of various residuals, or the use of materials and energy. (SEEA-2003 para. 4.101).

Ecological approach to sustainable development: The notion that economic and social systems are sub-systems of the global environment. It follows that sustainability in the economic and social spheres is subordinate to sustainability of the environment. The key property to be sustained is the capacity of ecosystems to respond with resilience to external perturbations and changes. (SEEA-2003 para. 1.13).

Economic assets: Entities functioning as stores of value and over which ownership rights are enforced by institutional units, individually or collectively, and from which economic benefits may be derived by their owners by holding them, or using them, over a period of time (the economic benefits consist of primary incomes derived from the use of the asset and the value, including possible holding gains/losses, that could be realised by disposing of the asset or terminating it). (1993 SNA paras. 10.2, 13.12 [11.16]).

Economic flows: The creation, transformation, exchange, transfer or extinction of economic value. Economic flows involve changes in the volume, composition, or value of an institutional unit's assets and liabilities. (1993 SNA para. 3.9).

Economic instruments: Also called 'market instruments', correspond to economic means by which decisions or actions of government affect the behaviour of producers and consumers by causing changes in the prices to be paid for these activities. (SEEA-2003 para. 6.5).

Economic production: Activity carried out under the control and responsibility of an institutional unit that uses inputs of labour, capital, and goods and services to produce outputs of goods or services. (1993 SNA para. 6.15).

Economic rent: Value of capital service flows due to both produced and non-produced assets. Equals gross operating surplus. (SEEA-2003 para. 7.161).

Economic sphere: Includes all flows related to the three types of economic activity covered in national accounts (production, consumption and accumulation). All flows of products belong to the economic sphere. (SEEA-2003 para. 3.79).

Economic territory (of a country): The geographic territory administered by a government within which persons, goods, and capital circulate freely; it includes: (a) the airspace, territorial waters, and continental shelf lying in international waters over which the country enjoys exclusive rights or over which it has, or claims to have, jurisdiction in respect of the right to fish or to exploit fuels or minerals below the sea bed; (b) territorial enclaves in the rest of the world; and (c) any free zones, or bonded warehouses or factories operated by offshore enterprises under customs control (these form part of the economic territory of the country in which they are physically located). (1993 SNA para. 14.9)

Economically significant prices: Prices that have a significant influence on the amounts the producers are willing to supply and on the amounts purchasers wish to buy. (1993 SNA para. 6.45 [4.58])

Economy-wide MFA: See *material flow accounts*.

Ecosystem inputs: Includes the substances absorbed from the ecosystem for purposes of production and consumption such as the gases needed for combustion and production processes as well as oxygen, carbon dioxide, water and nutrients. (SEEA-2003 paras. 3.11, 3.42).

Ecosystem services: Includes the provision of ecosystem inputs, the assimilative capacity of the environment and the provision of biodiversity. (SEEA-2003 para. 3.42).

Ecosystems: Groups of organisms and the physical environment they inhabit. Three main types of ecosystem assets are recognised in the SEEA; terrestrial ecosystems, aquatic ecosystems and atmospheric systems. (SEEA-2003 para. 7.73, EA.3).

Emissions permits: The right to generate a certain amount of specific emissions in the course of production activity, for example greenhouse gases. Emissions permits are a form of intangible non-produced assets and are sometimes tradable. (SEEA-2003 para. 6.53).

End of pipe technologies expenditure: Expenditure on “end-of-pipe” technologies are directed to treat, handle or dispose of emissions and wastes from production. This type of spending could be normally easily identified even within the context of ancillary activity because it is usually directed toward an “add on” facility, which removes, transforms or reduces emissions and discharges at the end of the production process. (SEEA-2003 para. 5.98).

Energy accounts: Accounts that show the supply and use of energy, by type of energy, and categories of supply and use. (SEEA-2003 para. 4.67).

Environment industry: The manufacturers and suppliers of environmental goods and services are collectively referred to as the environment industry which cuts across conventional industrial classifications. The industry consists of activities which produce goods and services to measure, prevent, limit, minimize or correct environmental damage to water, air and soil as well as problems related to waste, noise and ecosystems. This includes cleaner technologies, products and services that reduce environmental risk and minimize pollution and resource use as well as activities related to resource management, resource exploitation and natural hazards. (SEEA-2003 paras. 5.86, 5.87).

Environmental asset accounts: Accounts that describe in physical and/or monetary units the stocks and changes in stocks of environmental assets. (SEEA-2003 para. 7.91).

Environmental assets: Entities from which use and non use benefits may be derived. They include natural resources, land and surface water, and ecosystems. (SEEA-2003 para. 7.35).

Environmental debt: Unremedied degradation that carries forward to a future period. (SEEA-2003 para. 10.162).

Environmental -economic profiles: See *eco-efficiency profiles*.

Environmental functions: Functions provided by the environment. They correspond to the various uses to which naturally produced physical surroundings are put for economic ends. Three types of environmental functions are distinguished: resource functions, sink functions and service functions. (SEEA-2003 paras. 7.31, 7.35).

Environmental products: Products of environmental activities as well as the specific products used for intermediate consumption or fixed capital formation of environmental activities. Also included are connected and adapted products. (SEEA-2003 para. 5.79).

Environmental protection activities: Activities whose primary purpose is the protection of the environment; that is, the avoidance and reduction of the negative effects on the environment caused by economic activities. The activities are generally classified according to the classification of environmental protection activities (CEPA 2000). (SEEA-2003 para. 5.29).

Environmental protection capital stock: Capital stock used for environmental protection activities, which allows for the calculation of the consumption of fixed capital or the depreciation of environmental protection capital stocks. (SEEA-2003 para. 5.112).

Environmental protection expenditure accounts (EPEA): Internal satellite account comprising production and generation of income accounts and supply and use table for environmental protection activities and products. (SEEA-2003 para. 5.95).

Environmental protection input-output table: Symmetric table that builds a bridge between the physical input-output table and environmental protection expenditure, separating internal and external environmental protection services and fixed capital formation for environmental protection. (SEEA-2003 para. 5.202).

Environmental sphere: Includes all physical entities other than products and corresponding flows. The environmental sphere provides resources to, and receives residuals from, one or more national economies. (SEEA-2003 para. 3.80).

Environmental taxes: A tax whose tax base is a physical unit (or a proxy of it) that has a proven specific negative impact on the environment. Four subsets of environmental taxes are distinguished: energy taxes, transport taxes, pollution taxes and resources taxes. Taxes should not be confounded neither with payments of rent nor with fees for purchase of an environmental protection service. (SEEA-2003 paras. 2.102, 6.26).

Environmental theme: A specific environmental phenomena or concern, such as: greenhouse effect, ozone layer depletion, acidification, eutrophication, etc. Various residuals are converted into theme equivalents using conversion factors. (SEEA-2003 para. 4.94).

Environmentally adjusted aggregates: Aggregates that adjust standard national accounts aggregates for depletion and/or degradation (e.g. "Green GDP", Genuine Savings). (SEEA-2003 para. 2.153).

Exclusive economic zone (EEZ): Area adjacent to a coastal state which encompasses all waters between: (a) the seaward boundary of that state, (b) a line on which each point is 200 nautical miles (370.40 km) from the baseline from which the territorial sea of the coastal state is measured (except when other international boundaries need to be accommodated), and (c) the maritime boundaries agreed between that state and the neighbouring states. (SEEA-2003 para. 8.247; FAO).

Existence benefit: Benefit provided by an environmental entity the existence of which is considered desirable to be maintained although it has no prospect of being of use to humans now or in the future. (SEEA-2003 para. 7.38).

Exports of goods and services: Sales, barter, or gifts or grants, of goods and services from residents to non-residents; the treatment of exports and imports in the SNA is generally identical with that in the balance of payments accounts as described in the Balance of Payments Manual. (1993 SNA para. 14.88 [14.91, 14.94]).

External satellite accounts: Extend the scope of the 1993 SNA by including stocks, flows and transactions, which are not covered by the core framework. (SEEA-2003 para. 2.11).

Externalisation of environmental protection ancillary activities: Ancillary activity is treated as if it were an external activity, identifying all the costs, including labour input and the consumption of materials and fixed capital related to the activity. The value of the ancillary output is then set equal to the costs incurred and is treated as intermediate consumption in much the same way as an external purchase of services by the establishment. (SEEA-2003 para. 5.75).

Extra cost criterion: One of four alternative criteria used to define environmental protection expenditures. The other three criteria are the pure purpose criterion, the compliance criterion, and the net-cost criterion. The extra cost criterion refers to the cost difference between a more environmentally friendly technology or a change in production process or product, such as the investment and operating expenditures compared to those of a 'standard' or less environmentally beneficial alternative, if there is one, or the additional estimated cost of incorporating the environmentally beneficial feature. (SEEA-2003 para. 5.30).

Final consumption: Goods and services used up by individual households or the community to satisfy their individual or collective needs or wants. (1993 SNA para. 1.49).

Final consumption expenditure of government: Expenditure, including imputed expenditure, incurred by general government on both individual consumption goods and services and collective consumption services. (1993 SNA para. 9.94).

Final consumption expenditure of households: Expenditure, including imputed expenditure, incurred by resident households on individual consumption goods and services, including those sold at prices that are not economically significant. (1993 SNA para. 9.94).

Financial lease: Contract between lessor and lessee whereby the lessor purchases a good that is put at the disposal of the lessee and the lessee pays rentals that enable the lessor, over the period of the contract, to cover all, or virtually all, costs, including interest; all the risks and rewards of ownership are, de facto, transferred from the legal owner of the good (the lessor) to the user of the good (the lessee). (1993 SNA para. 13.23 [6.118, 7.107, 10.44]).

Fish stock: Living resources in the community or population from which catches are taken in a fishery. Use of the term fish stock usually implies that the particular population is more or less isolated from other stocks of the same species and hence self-sustaining. In a particular fishery, the fish stock may be one or several species of fish but here is also intended to include commercial invertebrates and plants. (SEEA-2003 para. 8.280; FAO).

Fishing rights/licences: Right to exploit fishing grounds over more than one year. When they are transferable, fishing rights constitute an intangible non-produced asset. Fishing rights must be distinguished from fishing licences. Fishing licenses are payable annually and cover the right to fish in specific waters only for the year covered and their payment should be regarded as a form of rent and not as the acquisition of an asset. (SEEA-2003 paras. 6.36, 6.49).

Fixed assets: Tangible or intangible assets produced as outputs from processes of production that are themselves used repeatedly or continuously in other processes of production for more than one year. (1993 SNA para. 10.33 [1.49, 10.7, 10.26, 13.15]).

Forest accounts for timber: Shows the opening and closing stocks of standing timber and the changes between the beginning and the end of the accounting period in physical and in monetary terms. (SEEA-2003 para. 8.182).

Forested land: Land with tree crown cover (or equivalent stocking level) of more than 10 per cent and an area of more than 0.5 hectares. The trees should be able to reach a minimum height of 5 metres at maturity in situ. (SEEA-2003 para. 8.152).

Forested land available for wood supply: Areas where legal, economic, or environmental restrictions do not have a significant impact on the supply of wood. It includes areas where harvesting of timber is not taking place, for example, because of long term utilisation plans or intentions. (SEEA-2003 para. 8.158).

Forested land not available for wood supply: Areas where legal, economic, or environmental restrictions prevent any significant wood production. Legal and/or environmental restrictions refer to protection for environmental and biodiversity conservation and other protection, including restrictions to ensure protection against soil erosion, avalanches and so on, and for special environmental, scientific, historical, cultural or spiritual interest. Economic restrictions appear in areas where physical productivity or wood quality is too low or harvesting and transport costs are too high to warrant wood harvesting, apart from occasional cuttings for own consumption. (SEEA-2003 para. 8.157).

Functional classifications: Means of classifying, by purpose or socio-economic objective, certain transactions of producers and of three institutional sectors - namely households, general government and non-profit institutions serving households (NPISHs). (1993 SNA para. 18.1).

General government: Totality of institutional units which, in addition to fulfilling their political responsibilities and their role of economic regulation, produce principally non-market services (possibly goods) for individual or collective consumption and redistribute income and wealth. (1993 SNA para. 2.20).

Generation of income account: Shows the types of primary incomes and the sectors, sub-sectors or industries in which the primary incomes originate, as distinct from the sectors or sub-sectors destined to receive such incomes. (1993 SNA para. 7.3).

Global warming potential: Weighted aggregate measure of the contribution to the greenhouse effect of gases through their conversion into carbon dioxide equivalent. (SEEA-2003 para. 3.27).

Goods and services account: Shows for the economy as a whole and for groups of products, the total resources in terms of output and imports, and the uses of goods and services in terms of intermediate consumption, final consumption, gross capital formation and exports. (1993 SNA para. 15.5).

Government units: Unique kinds of legal entities established by political processes which have legislative, judicial or executive authority over other institutional units within a given area. (1993 SNA para. 4.104 [4.19]).

Gross annual increment: Average annual volume of increment over the reference period of all trees, with no minimum diameter, which is thus equivalent to natural growth in a year. (SEEA-2003 para. 8.179).

Gross capital formation: Measured by the total value of the gross fixed capital formation, changes in inventories and acquisitions less disposals of valuables for a unit or sector. (1993 SNA para. 10.32).

Gross domestic product - expenditure based: Total final expenditures at purchasers' prices (including the f.o.b. value of exports of goods and services), less the f.o.b. value of imports of goods and services. (1993 SNA para. 6.235).

Gross domestic product - income based: Calculated as compensation of employees, plus taxes less subsidies on production and imports, plus gross mixed income, plus gross operating surplus. (1993 SNA para. 2.222).

Gross domestic product - market prices: Sum of the gross values added of all resident producers at market prices, plus taxes less subsidies on imports. (1993 SNA para. 6.235).

Gross domestic product - output based: Sum of the gross values added of all resident producers at basic prices, plus all taxes less subsidies on products. (1993 SNA paras. 6.235, 6.236, 6.237).

Gross fixed capital formation: Measured by the total value of a producer's acquisitions, less disposals, of fixed assets during the accounting period plus certain additions to the value of non-produced assets (such as subsoil assets or major improvements in the quantity, quality or productivity of land) realised by the productive activity of institutional units. (1993 SNA paras. 10.33, 10.51 [10.26]).

Gross national disposable income: May be derived from gross national income by adding all current transfers in cash or in kind receivable by resident institutional units from non-resident units and subtracting all current transfers in cash or in kind payable by resident institutional units to non-resident units. (1993 SNA para. 8.16 [2.183]).

Gross national income (GNI): Gross domestic product less net taxes on production and imports, less compensation of employees and property income payable to the rest of the world plus the corresponding items receivable from the rest of the world (in other words, GDP less primary incomes payable to non-resident units plus primary incomes receivable from non-resident units); an alternative approach to measuring GNI at market prices is as the aggregate value of the balances of gross primary incomes for all sectors. (1993 SNA paras. 2.18, 7.16, Table 7.2 [2.181]).

Gross operating surplus: See *operating surplus*.

Gross removal: In aquatic resources accounts, total live weight of fish caught or killed during fishing operation. (SEEA-2003 para. 8.295, Figure 8.4).

Gross residual flow: Quantity of residuals generated by all units in the national economy during an accounting period (including leakages from managed landfill sites). (SEEA-2003 para. 3.55).

Gross saving: Gross disposable income less final consumption expenditure. (1993 SNA para. 9.2).

Gross value added: Value of output less the value of intermediate consumption; it is a measure of the contribution to GDP made by an individual producer, industry or sector; gross value added is the source from which the primary incomes of the SNA are generated and is therefore carried forward into the primary distribution of income account. (1993 SNA para. 1.6 [2.172, 6.4, 6.222]).

Gross value added at basic prices: Output valued at basic prices less intermediate consumption valued at purchasers' prices. (1993 SNA paras. 6.226, 15.37 [6.231]).

Gross value added at producers' prices: Output valued at producers' prices less intermediate consumption valued at purchasers' prices. (1993 SNA paras. 6.227, 15.37).

Growing stock: The living component of the standing volume. (SEEA-2003 para. 8.179).

Hedonic method: A regression technique used to estimate the prices of qualities or models that are not available on the market in particular periods, but whose prices in those periods are needed in order to be able to construct price relatives; it is based on the hypothesis that the prices of different models on sale on the market at the same time are functions of certain measurable characteristics such as size, weight, power, speed, etc and so regression methods can be used to estimate by how much the price varies in relation to each of the characteristics. (1993 SNA para. 16.126).

Holding gains: May accrue during the accounting period to the owners of financial and non-financial assets and liabilities as a result of a change in their prices (holding gains are sometimes referred to as "capital gains"). They can be positive or negative. (1993 SNA para. 3.62).

Homogeneous production unit: Producer unit in which only a single (non-ancillary) productive activity is carried out; this unit is not normally observable and is more an abstract or conceptual unit underlying the symmetric (product-by-product) input-output tables. (1993 SNA para. 15.14).

Hybrid flow accounts: Single matrix account containing both national accounts in monetary terms and physical flow accounts showing the absorption of natural resources and ecosystem inputs and the generation of residuals. The account records physical flows compatible with economic transactions as presented in national accounts, which would guarantee a consistent comparison of environmental burdens to economic benefits, or environmental benefits to economic costs. See *hybrid input-output table* and *hybrid supply and use tables*. (SEEA-2003 para. 4.4).

Hybrid input-output tables: Table where the SNA monetary input output table is combined with the corresponding physical input output table. (SEEA-2003 para. 4.12).

Hybrid supply and use tables: Particular form of matrix accounting which includes in the same table monetary flows relating to products and physical flows relating to natural resources, ecosystem inputs and residual generation. (SEEA-2003 paras. 2.69, 4.8).

Hydrological cycle: Succession of stages through which water passes from the atmosphere to the earth and returns to the atmosphere: evaporation from the land or sea or inland water, condensation to form clouds, precipitation, accumulation in the soil or in bodies of water, and re-evaporations. (SEEA-2003 para. 8.75).

Imports of goods and services: Purchases, barter, or receipts of gifts or grants, of goods and services by residents from non-residents; the treatment of exports and imports in the SNA is generally identical with that in the balance of payments accounts as described in the Balance of Payments Manual. (1993 SNA para. 14.88 [14.9, 14.94]).

Improvements to land: Acquisitions that lead to major improvements in the quantity, quality or productivity of land, or prevention of its deterioration, are treated as gross fixed capital formation. They consist of acquisitions related to the following kinds of activities: (a) Reclamation of land from the sea by the construction of dykes, sea walls or dams for this purpose; (b) Clearance of forests, rocks, etc. to enable land to be used in production for the first time; (c) Draining of marshes or the irrigation of deserts by the construction of dykes, ditches or irrigation channels; (d) Prevention of flooding or erosion by the sea or rivers by the construction of breakwaters, sea walls or flood barriers. (1993 SNA para. 10.51).

Imputed expenditure: Some transactions which it is desirable to include in the accounts do not take place in money terms and so cannot be measured directly; in such cases a conventional value is imputed to the corresponding expenditure. (1993 SNA para. [3.34, 9.30]).

Income: Maximum amount that a household, or other unit, can consume without reducing its real net worth provided the net worth at the beginning of the period is not changed by capital transfers, other changes in the volume of assets or real holding gains or losses. (1993 SNA para. 8.15).

Income – Hicksian concept: Maximum amount an individual can consume during a period and remain as well off at the end of the period as at the beginning. (SEEA-2003 para. 1.18).

Indirect use benefit: Benefits that do not change the physical characteristics of the environment and are sometimes described as being “non-consumptive”. One typical example is the amenity benefit of landscape. (SEEA-2003 para. 7.36).

Individual quota: Quota (possibly a percentage) of a total allowable catch (TAC) assigned to an individual, a vessel or a company. If an individual quota is transferable, it is referred to as an individual transferable quota (ITQ). (SEEA-2003 para. 8.292; FAO).

Individual transferable quota (ITQ): Type of quota (a part of a total allowable catch) allocated to individual fishermen or vessel owners and which can be sold to others. (SEEA-2003 para. 7.273; FAO).

Individual transferable share quota (ITSQ): Management tool used to allocate a fixed share of the quota to individual fishermen or companies. ITSQs are usually granted as a form of long-term fishing rights and are tradable (transferable). (SEEA-2003 para. 7.273; FAO).

Industry: Group of establishments engaged on the same, or similar, kinds of production activity; the classification of productive activities used in the SNA is ISIC (Rev.3). (1993 SNA paras. 5.5, 5.40).

Industry-by-industry table: Symmetric input-output table with industries as the dimension of both rows and columns; as a result it shows which industry uses the output of which other industry. (1993 SNA para. 15.150).

Input-output table: Means of presenting a detailed analysis of the process of production and the use of goods and services (products) and the income generated in that production; can be either in the form of (a) supply and use tables or (b) symmetric input-output tables. (1993 SNA paras. 15.1, 15.8 [2.211, 15.2]).

Institutional sectors: Groups of institutional units, on the basis of their principal functions, behaviour, and objectives. (1993 SNA para. 2.20).

Institutional unit: Economic entity capable, in its own right, of owning assets, incurring liabilities and engaging in economic activities and in transactions with other entities. (1993 SNA para. 4.2 [1.13, 2.19, 3.13]).

Intangible fixed assets: Non-financial produced fixed assets that mainly consist of mineral exploration, computer software, entertainment, literary or artistic originals intended to be used for more than one year. (1993 SNA, AN.112).

Intangible non-produced assets: Assets that entitle their owners to engage in certain specific activities or to produce certain specific goods or services and to exclude other institutional units from doing so except with the permission of the owner (e.g. patented entities or purchased goodwill). (1993 SNA para. 13.62, AN.22).

Interest: Amount that the debtor becomes liable to pay to the creditor over a given period of time without reducing the amount of principal outstanding, under the terms of the financial instrument agreed between them. (1993 SNA para. 7.93).

Intermediate consumption: Value of the goods and services consumed as inputs by a process of production, excluding fixed assets whose consumption is recorded as consumption of fixed capital; the goods or services may be either transformed or used up by the production process. (1993 SNA para. 6.147).

Internal satellite account: Rearrangement of the existing SNA transactions. SNA flows are presented and aggregated differently and in some case separated out from existing records by a process of "deconsolidation". (SEEA-2003 para. 2.11).

Inventories: Stocks of outputs that are still held by the units that produced them prior to their being further processed, sold, delivered to other units or used in other ways, and stocks of products acquired from other units that are intended to be used for intermediate consumption or for resale without further processing. (1993 SNA para. 10.7 [13.15, 13.46], AN.12).

Inventories - changes in (including work-in-progress): Consist of changes in: (a) stocks of outputs that are still held by the units that produced them prior to their being further processed, sold, delivered to other units or used in other ways; and (b) stocks of products acquired from other units that are intended to be used for intermediate consumption or for resale without further processing; they are measured by the value of the entries into inventories less the value of withdrawals and the value of any recurrent losses of goods held in inventories. (1993 SNA paras. 10.7, 10.28).

Inventories of work-in progress: Goods and services that are partially completed but that are not usually turned over to other units without further processing or that are not mature and whose production process will be continued in a subsequent period by the same producer. (1993 SNA, AN.122, para. [6.40, 6.72, 10.102]).

Inventories of work-in progress on cultivated assets: Livestock raised for products yielded only on slaughter, such as fowl and fish raised commercially, trees and other vegetation yielding once-only products on destruction and immature cultivated assets yielding repeat products. (1993 SNA, AN.1221).

Investment grants: Capital transfers in cash or in kind made by governments to other resident or non-resident institutional units to finance all or part of the costs of their acquiring fixed assets. (1993 SNA para. 10.137).

Kind-of-activity unit: Enterprise, or a part of an enterprise, which engages in only one kind of (non-ancillary) productive activity or in which the principal productive activity accounts for most of the value added. (1993 SNA para. 5.19).

Land: Ground, including the soil covering and any associated surface waters, over which ownership rights are enforced; included are major improvements that cannot be physically separated from the land itself but it excludes any buildings or other structures situated on it or running through it; cultivated crops, trees and animals; subsoil assets; non-cultivated biological resources and water resources below the ground. (1993 SNA, AN.211, para. [13.54]).

Land and surface water: Areas within the national territory that provide direct or indirect use benefits (or that may provide such benefits one day) through the provision of space for economic and non-economic (for example recreational) human activities. Land and surface water assets are sub-divided into five categories: land underlying buildings and structures; agricultural land and associated surface water; wooded land and associated surface water; major water bodies; and other land. (SEEA-2003 para. 7.61, EA.2).

Land (basic accounts): Relate the use of land and land cover from an environmental perspective, in terms of stocks and changes in stocks. In particular they show the changes in land classified to each type of land cover over a period with identification as to whether this is due to human or natural processes. (SEEA-2003 para. 8.337).

Land cover: Reflects the (bio) physical dimension of the earth's surface and corresponds in some regard to the notion of ecosystems. Typical examples for land cover categories are built-up areas, grassland, forests or rivers and lakes. (SEEA-2003 para. 8.322).

Land cover change matrix: Cross-tabulates land cover at two different points in time. It shows how much of the opening stock of a land cover category remains unchanged in the closing stock and the gross flows between the different categories of land cover. (SEEA-2003 para. 8.345).

Land supplementary accounts: Accounts that differentiate land basic accounts in a consistent way by more detailed description of issue oriented aspects like sealing of soil, partitioning (fragmentation) of land, intensity of use, biotopes, quality, regional situations, etc. (SEEA-2003 paras. 8.336, 8.356).

Land under cultivation: Land on which agricultural or horticultural production is carried on for commercial or subsistence purposes, including land under plantations, orchards and vineyards. (1993 SNA, AN.2112).

Land underlying buildings and structures: Land on which dwellings, non-residential buildings and structures are constructed or into which their foundations are dug, including yards and gardens deemed an integral part of farm and non-farm dwellings and access roads to farms. (1993 SNA, AN.2111).

Land underlying buildings and structures within urban areas: The SEEA asset classification of land underlying buildings and structures identifies sub-categories: within urban areas and outside urban areas. The definition of an urban area will vary from country to country, but a working definition is any area where at the time of the most recent census there was a population of 1000 or more persons and a population density of 400 or more persons per square kilometre. (SEEA-2003 para. 7.63, EA.21).

Landfill site: A place where residuals are disposed of. In SEEA, landfill sites are treated as physical capital formation. (SEEA-2003 para. 3.49).

Landings: Weight of what is landed at a landing site. It may be different from the catch (which includes the discards). (SEEA-2003 para. 8.296, Figure 8.4; FAO).

Leases and other transferable contracts: Leases or contracts where the lessee has the right to convey the lease to a third party independently of the lessor. Examples include leases of land and buildings and other structures, concessions or exclusive rights to exploit mineral deposits or fishing grounds, transferable contracts with athletes and authors and options to buy tangible assets not yet produced. Leases on the rental of machinery are excluded from non-financial intangible assets. (1993 SNA, AN.222).

Livestock for breeding, dairy, draught etc.: Livestock that are cultivated for the products they provide year after year. (1993 SNA, AN.11141).

Local government: Institutional units whose fiscal, legislative and executive authority extends over the smallest geographical areas distinguished for administrative and political purposes. (1993 SNA para. 4.128).

McKelvey box: A table showing subsoil assets cross classified according to economic viability of extraction and probability of existence of the reserves. (SEEA-2003 para. 8.25).

Maintenance cost approach: Cost-based method for valuing degradation, which measures the hypothetical costs that would have been incurred to attain some standard of environmental quality. They comprise avoidance costs – structural adjustment costs and abatement - and restoration costs. (SEEA-2003 paras. 2.176, 9.35, 10.171, 10.184).

Market output: Output that is sold at prices that are economically significant or otherwise disposed of on the market or intended for sale or disposal on the market for transactions. (1993 SNA para. 6.45).

Market prices: Amounts of money willing buyers pay to acquire something from willing sellers. (1993 SNA para. 2.68).

Market producers: Producers that sell most or all of their output at prices that are economically significant. (1993 SNA para. 4.58 [6.52]).

Mass balance: A specific supply and use table where different physical flows for products and/or residuals are expressed in a common specific unit; for example timber, forests products and wood waste are converted into 'dry-matter tonnes of wood'. (SEEA-2003 para. 3.188).

Material flow accounts (MFA): Describe material flow into and out of the economy in tonnes. It includes direct flows, which cross either the border between the national environment and the national economy (natural resources) or the border between the rest of the world economy and the national economy (imported products) and indirect flows, that happen either within the environment (mining overburden) or within the rest of the world (in particular resource extraction in other countries). They can be calculated at a level of aggregation economy-wide, as sum of material inputs or sum of material outputs from the economy. (SEEA-2003 para. 3.190).

Maximum economic yield (MEY) in fisheries accounts: When relating total revenues from fishing to total fishing effort in a surplus production model, the value of the largest positive difference between total revenues and total costs of fishing (including the cost of labour and capital) with all inputs valued at their opportunity costs. (SEEA-2003 para. 7.279; FAO).

Maximum sustainable yield (MSY) in fisheries accounts: The highest theoretical equilibrium yield that can be continuously taken (on average) from a renewable natural resource stock under existing (average) environmental conditions without affecting significantly the reproduction process. (SEEA-2003 para. 7.279; Adapted from FAO).

Mineral and energy resources: Subsoil deposits of fossil fuels, metallic minerals and non-metallic minerals. In the SEEA, these include not only the proven reserves but also probable, possible, potential and speculative resources. (SEEA-2003 paras. 7.147, 7.43, EA.11).

Mineral exploration: Value of expenditures on exploration for petroleum and natural gas and for non-petroleum deposits; it includes pre licence costs, licence and acquisition costs, appraisal costs and the costs of actual test drilling and boring, as well as the costs of aerial and other surveys, transportation costs, etc, incurred to make it possible to carry out the tests. (1993 SNA, AN.1121).

Monetary accounts: Accounts expressed in monetary units, using only currency as the unit of measure. (SEEA-2003 para. 1.40).

Monetary transactions: A transaction in which one institutional unit makes a payment (receives a payment) or incurs a liability (receives an asset) stated in units of currency. (1993 SNA para. 3.16).

National environment: The environment, corresponding to the economic territory, includes the surrounding sea area covered in an exclusive economic zone (EEZ) agreement and the airspace over the country. (SEEA-2003 para. 3.81).

National expenditure: Outlays on capital formation and final consumption grouped together constitute national expenditure. (1993 SNA para. 2.187).

National expenditure on environmental protection: Sum of:

- final and intermediate consumption of environmental protection products by resident units, other than those of the environmental protection producers themselves
- plus capital formation on environmental protection products
- plus gross capital formation on other products required for environmental protection activities
- plus (current and capital) specific transfers by residents units not captured in the items above
- plus (current and capital) financing provided by transfers to the rest of the world
- less financing by transfers received from the rest of the world. (SEEA-2003 para. 5.133).

National income: Total value of the primary incomes receivable within an economy less the total of the primary incomes payable by resident units. (1993 SNA para. 7.14).

National wealth: Sum, for the economy as a whole, of non-financial assets and net claims on the rest of the world. In the context of the SEEA, the concept of national wealth is extended to include all environmental assets, even those which are not within the SNA asset boundaries. (1993 SNA para. 13.2, SEEA-2003 para. 1.21).

Natural forests: Forests with natural species and ecological processes and for which there has been continuity of ecological processes over a very long period of time. The time period of continuity is sometimes quoted as being of more than 200 years but this may not be relevant for all types of forests. (SEEA-2003 para. 8.158).

Natural losses (timber): The average annual losses to the growing stock during the reference period due to mortality from other causes than cutting by man; for example, natural mortality, disease, insect attack, fire, wind-throw or other physical damages. (SEEA-2003 para. 8.179).

Natural resource management and exploitation activities: Management activities include research into management of natural resources, monitoring, control and surveillance, data collection and statistics, costs of the natural resource management authorities at various levels as well as temporary costs for facilitating structural adjustments of sectors concerned. Exploitation activities include abstraction, harvesting and extraction of natural assets including exploration and development. (SEEA-2003 paras. 5.39, 5.41).

Natural resources: Those elements of the environment that provide use benefits through the provision of raw materials and energy used in economic activity (or that may provide such benefits one day) and that are subject primarily to quantitative depletion through human use. They are subdivided into four categories: mineral and energy resources, soil resources, water resources and biological resources. It excludes land. (SEEA-2003 para. 7.42, EA.1).

Net additions to stock (NAS): This indicator measures the net stock changes in physical terms, i.e. physical growth rate of an economy. New materials are added to the economy's stock each year (gross additions), while old materials are removed from stock. (SEEA-2003 para. 3.207).

Net annual increment: The average annual volume over the reference period of gross increment less natural losses in forests accounts. (SEEA-2003 para. 8.179).

Net capital stock: Sum of the written-down values of all the fixed assets still in use. It can also be described as the difference between gross capital stock and consumption of fixed capital. (1993 SNA para. 6.199).

Net cost criterion: One of four alternative methods criteria used to define environmental protection expenditures. The other three criteria are the pure purpose criterion, the compliance criterion, and the extra -cost criterion. The net cost criterion refers only to expenditure undertaken for environmental protection purposes which lead to a net increase in cost (that is where spending exceeds any savings or income arising before the net cost was actually incurred) is included. Unlike the extra cost criterion, this criterion only applies to operating expenditure. (SEEA-2003 para. 5.30).

Net domestic product (NDP): Obtained by deducting the consumption of fixed capital from gross domestic product. (1993 SNA para. 2.175).

Net fixed capital formation: Gross fixed capital formation less consumption of fixed capital. (1993 SNA para. 10.27 [12.102]).

Net lending /borrowing: Net amount a unit or a sector has available to finance, directly or indirectly, other units or other sectors; it is the balancing item in the capital account and is defined as: (Net saving plus capital transfers receivable minus capital transfers payable) minus (the value of acquisitions less disposals of non-financial assets, less consumption of fixed capital); negative net lending may also be described as "net borrowing". (1993 SNA paras. 2.137, 10.30, Table 2.1).

Net national income: The aggregate value of the balances of net primary incomes summed over all sectors. (1993 SNA para. 7.16 [2.182], Table 7.2).

Net operating surplus: See *operating surplus*.

Net present value: The net present value of future income is obtained by applying a discount rate to the value of the future income flows. (SEEA-2003 para. 7.170).

Net price: The value of the resource stock is calculated as the current rent per unit of resources times the size of the stock, under the assumption that the resource rent will rise at a rate equal to the rate of discount. (SEEA-2003 para. 7.206).

Net rent: Total rent paid by a tenant to a landowner less the amounts paid by the landowner for land taxes or any maintenance expenses incurred solely as a consequence of owning the land (by convention, such taxes or expenses are treated as payable by the tenant who is deemed to deduct them from the rent that he would otherwise be obliged to pay to the landowner). (1993 SNA para. 7.130).

Net residual flow: The quantity of residuals that is ultimately rejected into the environment (or into a landfill site) following any recycling/re-use or predisposal treatment. (SEEA-2003 para. 3.55).

Net saving: Net disposable income less final consumption expenditure. (1993 SNA para. 9.2).

Net value added: Value of output less the values of both intermediate consumption and consumption of fixed capital. (1993 SNA paras. 6.4, 6.222 [1.6]).

Net value of a fixed asset: Equal to the actual or estimated current purchaser's price of a new asset of the same type less the cumulative value of the consumption of fixed capital accrued up to that point in time. (1993 SNA para. 6.199).

Net worth: Value of all the non-financial and financial assets owned by an institutional unit or sector less the value of all its outstanding liabilities; it is a measure of the wealth of a unit or sector at a point in time. (1993 SNA para. 3.68 [10.1, 13.10, 13.82]).

Neutral holding gain: Value of the holding gain that would accrue if the price of the asset changed in the same proportion as the general price level, i.e. merely kept pace with the general rate of inflation or deflation. (1993 SNA para. 12.64).

Nominal catch: Sum of catches that are landed (expressed as live weight equivalent). Nominal catches do not include unreported discards. (SEEA-2003 Figure 8.4; FAO).

Nominal holding gain: Value of the benefit accruing to the owner of a given quantity of an asset as a result of a change in its price or, more generally, its monetary value over time. (1993 SNA para. 12.63).

Nominal interest: Associated interest payments when a debtor is able to discharge his liability to the creditor by repaying principal equal in money value to the funds borrowed. (1993 SNA para. 7.109).

Non-cultivated biological resources: Animals and plants that yield both once-only and repeat products over which ownership rights are enforced but for which natural growth and/or regeneration is not under the direct control, responsibility and management of institutional units. For biological resources non-cultivated is synonym of non-produced. The SEEA adds non-cultivated resources that provide no current use benefit but that may one day do so (that is those with current option and bequest benefits). (1993 SNA, AN.213; SEEA-2003 para. 7.54).

Non-financial assets: Entities, over which ownership rights are enforced by institutional units, individually or collectively, and from which economic benefits may be derived by their owners by holding them, or using them over a period of time, that consist of tangible assets, both produced and non-produced, and most intangible assets for which no corresponding liabilities are recorded. (1993 SNA, AN).

Non-market output - other: Goods and individual or collective services produced by non-profit institutions serving households (NPISHs) or government that are supplied free, or at prices that are not economically significant, to other institutional units or the community as a whole; such output is one of three broad categories of output in the SNA, with the others being market output and output produced for own final use. (1993 SNA para. 6.49).

Non-market producers: Producers that provide most of their output to others free or at prices which are not economically significant. (1993 SNA para. 4.60 [6.52]).

Non-produced assets: Non-financial assets that come into existence other than through processes of production; they include both tangible assets and intangible asset. Natural (environmental assets) are tangible non-produced assets. (1993 SNA, AN.2, para. 10.6 [10.8, 13.17]).

Non-profit institutions (NPIs): Legal or social entities created for the purpose of producing goods and services whose status does not permit them to be a source of income, profit or other financial gain for the units that establish, control or finance them. (1993 SNA para. 4.54 [4.18, 4.161]).

Non-profit institutions serving households (NPISHs): NPIs which are not predominantly financed and controlled by government and which provide goods or services to households free or at prices that are not economically significant. (1993 SNA paras. 4.64, 4.65 [2.20]).

Non-resident: A unit whose centre of economic interest is not in the economic territory of a country. (1993 SNA para. [1.14]).

Non-use benefit: See *existence benefit*.

Operating lease: Agreement between a lessor and lessee for the rental of machinery or equipment for specified periods of time which are shorter than the total expected service lives of that machinery or equipment; the lessor normally maintains a stock of equipment in good working order which can be hired on demand, or at short notice, by users and is frequently responsible for the maintenance and repair of the equipment as part of the service which he provides to the lessee. (1993 SNA paras. 6.115, 6.116).

Operating surplus: Measures the surplus or deficit accruing from production before taking account of any interest, rent or similar charges payable on financial or tangible non-produced assets borrowed or rented by the enterprise, or any interest, rent or similar receipts receivable on financial or tangible non-produced assets owned by the enterprise. Operating surplus is measured either gross or net (after deduction of the consumption of fixed capital). (1993 SNA para. 7.8; SEEA-2003 para. 7.161).

Opportunity cost: Measured by reference to the opportunities foregone at the time an asset or resource is used, as distinct from the costs incurred at some time in the past to acquire the asset, or the payments which could be realised by an alternative use of a resource (e.g. the use of labour in a voluntary capacity being valued at the wages which could have been earned in a paid job). (1993 SNA para. 1.60).

Option benefit: Benefits derived from the continued existence of elements of the environment that may one day provide benefits for those currently living. (SEEA-2003 para. 7.37).

Other accumulation entries: Transactions and other economic flows not taken into account elsewhere which change the quantity or value of assets and liabilities; they include consumption of fixed capital and acquisitions less disposals of non-produced non-financial assets; other economic flows of non produced assets, such as discovery or depletion of subsoil resources or transfers of other natural assets to economic activities; the effects of non-economic phenomena such as natural catastrophes and political events (wars for example); and holding gains or losses due to changes in prices. (1993 SNA para. 2.33).

Other changes in assets account: Consist of two sub-accounts: the other changes in volume of assets account and the revaluation account; it records changes in the values of assets, liabilities, and net worth between opening and closing balance sheets that result from other flows, i.e. flows that are not transactions. (1993 SNA paras. 1.9, 12.1).

Other changes in stock levels: The entry of the SEEA asset account which covers those changes in stock level which cannot be attributed to the interaction between the economy and the environment, as well as one which is simply related to the change in ownership from one economic unit to another; it covers catastrophic losses, uncompensated seizures, degradation of produced assets, nominal holding gains and losses and changes in classification for that part which corresponds to the change of ownership. (SEEA-2003 para. 7.112).

Other changes in the volume of assets account: Records the changes in assets, liabilities, and net worth between opening and closing balance sheets that are due neither to transactions between institutional units, as recorded in the capital and financial accounts, nor to holding gains and losses. (1993 SNA para. 12.4 [1.9, 3.58 - 3.61]).

Other environmental products: Consists of connected products and adapted products. See *connected products* and *adapted products*. (SEEA-2003 para. 5.83).

Other intangible fixed assets: New information, specialised knowledge, etc, not elsewhere classified, whose use in production is restricted to the units that have established ownership rights over them or to other units licensed by the latter. (1993 SNA, AN.1129).

Other intangible non produced assets: Intangible non-produced assets not elsewhere classified. (1993 SNA, AN.229).

Other subsidies on production: Subsidies, except subsidies on products, which resident enterprises may receive as a consequence of engaging in production (e.g. subsidies on payroll or workforce or subsidies to reduce pollution). (1993 SNA para. 7.79).

Other subsidies on products (other than export or import subsidies): Subsidies on goods or services produced as the outputs of resident enterprises that become payable as a result of the production, sale, transfer, leasing or delivery of those goods or services, or as a result of their use for own consumption or own capital formation; there are three broad categories: (a) subsidies on products used domestically, (b) losses of government trading organisations, and (c) subsidies to public corporations and quasi-corporations. (1993 SNA para. 7.78).

Other taxes on production: Taxes other than those incurred directly as a result of engaging in production; they mainly consist of current taxes on the labour or capital employed in the enterprise, such as payroll taxes or current taxes on vehicles or buildings. (1993 SNA para. 6.229).

Output: Goods or services that are produced within an establishment that become available for use outside that establishment, plus any goods and services produced for own final use. (1993 SNA para. 6.38).

Output produced for own final use: Goods or services retained for their own final use by the owners of the enterprises in which they are produced. (1993 SNA para. 6.46).

Ozone depleting potential: The weighted measure of the ozone layer depleting potential of substances, calculated through the conversion of halogenated hydrocarbons into CFC-11 equivalent. (SEEA-2003 para. 3.28).

Perpetual inventory method (PIM): Method of constructing estimates of capital stock and consumption of fixed capital from time series of gross fixed capital formation; it allows an estimate to be made of the stock of fixed assets in existence and in the hands of producers which is generally based on estimating how many of the fixed assets installed as a result of gross fixed capital formation undertaken in previous years have survived to the current period; a PIM approach is also commonly used in valuing changes in inventories. (1993 SNA para. 6.189 [6.58]).

Physical accounts: Accounts expressed in physical units. They may employ any linear, volumetric, area or mass units used in the International System of Units (for example metres, litres, hectares, kilograms). (SEEA-2003 para. 1.40).

Physical input-output tables (PIOT): Symmetric matrix that shows physical flows (for all materials or a subset of materials) from the environment or rest of the world to the economy, within the economy and from the economy to the rest of the world. (SEEA-2003 para. 3.209).

Physical supply and use tables (PSUT): Matrices in physical units that record the flows of ecosystem inputs, natural resources, products and residuals according to their origin (environment, domestic industries and imports) and their destination (intermediate or final uses, exports and the environment). (SEEA-2003 para. 3.96).

Physical trade balance (PTB): An indicator that measures the physical trade surplus or deficit of an economy. PTB equals imports minus exports. Physical trade balances may also include hidden flows associated with imports and exports. (SEEA-2003 para. 3.208).

Plantations: Forests for intensive fuel or industrial wood production planted or artificially regenerated and made up of exotic (non-indigenous) species and/or mono-cultures. (SEEA-2003 para. 8.158).

Pollution damage to human health: The value of the damage to human health due to the degradation of the environment. This value, related to pollution-linked morbidity and excess mortality, is generally calculated by combining the dose-response technique and various valuation methods. (SEEA-2003 para. 10.155).

Possible reserves: Reserves where there is considerable doubt over the technical and or financial viability of extraction. (SEEA-2003 para. 8.25).

Potential reserves: Reserves that are known to exist but thought to be not technically or economically feasible to extract. (SEEA-2003 para. 8.25).

Primary incomes: Incomes that accrue to institutional units as a consequence of their involvement in processes of production or ownership of assets that may be needed for purposes of production. (1993 SNA para. 7.2).

Primary purpose criterion: In order to be included in environmental protection, an activity, a product or a transaction must have environmental protection as its primary purpose. Four variants or sub-sets are used either in combination or separately. The four sub-sets are the pure purpose criterion, the extra-cost criterion, the net-cost criterion and the compliance criterion. (SEEA-2003 para. 5.30).

Principal activity: Activity whose value added exceeds that of any other activity carried out within the same unit (the output of the principal activity must consist of goods or services that are capable of being delivered to other units even though they may be used for own consumption or own capital formation). (1993 SNA para. 5.7 [15.16]).

Probable reserves: Reserves which are known to exist but where some doubt exists over whether they are technically or economically viable. (SEEA-2003 para. 8.25).

Produced assets: Non-financial assets that have come into existence as outputs from processes that fall within the production boundary of the SNA; produced assets consist of fixed assets, inventories and valuables. (1993 SNA, AN.1, paras. 10.6, 10.7 [13.14]).

Producer's price: Amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any VAT, or similar deductible tax, invoiced to the purchaser; it excludes any transport charges invoiced separately by the producer. (1993 SNA paras. 6.205, 15.28 [3.82]).

Product-by-product table: Symmetric input-output table with products as the dimension of both rows and columns; as a result it shows which products are used in the production of which other products. (1993 SNA para. 15.150).

Production: Activity, carried out under the responsibility, control and management of an institutional unit that uses inputs of labour, capital and goods and services to produce outputs of goods and services. (1993 SNA para. 6.15 [1.20, 5.4, 6.6]).

Production account: Records the activity of producing goods and services as defined within the SNA; its balancing item, gross value added, is a measure of the contribution to GDP made by an individual producer, industry or sector. (1993 SNA para. 1.6).

Production boundary: Includes (a) the production of all individual or collective goods or services that are supplied to units other than their producers, or intended to be so supplied, including the production of goods or services used up in the process of producing such goods or services; (b) the own-account production of all goods that are retained by their producers for their own final consumption or gross capital formation; (c) the own-account production of housing services by owner-occupiers and of domestic and personal services produced by employing paid domestic staff. (1993 SNA para. 6.18 [1.20, 1.22]).

Products: Products, also called "goods and services", are the result of production; they are exchanged and used for various purposes: as inputs in the production of other goods and services, as final consumption or for investment. (1993 SNA para. 2.49).

Property income: Income receivable by the owner of a financial asset or a tangible non-produced asset in return for providing funds to or putting the tangible non-produced asset at the disposal of, another institutional unit; it consists of interest, the distributed income of corporations (i.e. dividends and withdrawals from income of quasi-corporations), reinvested earnings on direct foreign investment, property income attributed to insurance policy holders, and rent. (1993 SNA paras. 7.88, 7.89 [7.2]).

Property rights: An intangible non-produced asset which entitles its owner to use a specific asset for a productive activity during more than one year. (SEEA-2003 para. 6.45).

Proven reserves: Reserves where it is known that it is both technically feasible and economically viable to extract the oil. (SEEA-2003 para. 8.25).

Purchased goodwill: Difference between the value paid for an enterprise as a going concern and the sum of its assets less the sum of its liabilities, each item of which has been separately identified and valued; the value of goodwill includes anything of long-term benefit to the business that has not been separately identified as an asset, as well as the value of the fact that the group of assets is used jointly and is not simply a collection of separable assets. (1993 SNA, AN.223, para. [12.22]).

Purchaser's price: Amount paid by the purchaser, excluding any deductible VAT or similar deductible tax, in order to take delivery of a unit of a good or service at the time and place required by the purchaser; the purchaser's price of a good includes any transport charges paid separately by the purchaser to take delivery at the required time and place. (1993 SNA paras. 6.215, 15.28 [2.73, 3.83]).

Pure purpose criterion: One of four alternative criteria used to define environmental protection expenditures. The other three criteria are the net cost criterion, the compliance criterion, and the extra - cost criterion. The pure purpose criterion is a variant for identifying environmental expenditure, where the activities and expenditure are classified under environmental protection in so far their only objective is protecting the environment, for example end-of-pipe capital expenditure. (SEEA-2003 para. 5.30).

Quota (fisheries accounts): Share of the total allowable catch (TAC) allocated to an operating unit such as a country, a vessel, a company or an individual fisherman (individual quota). Quotas may or may not be transferable, inheritable, and tradable. While generally used to allocate TAC, quotas could be used also to allocate fishing effort or biomass. (FAO).

Real holding gain: Value of the additional command over real resources accruing to the holder of an asset as a result of a change in its price relatively to the prices of goods and services in general in the economy. (1993 SNA para. 12.64).

Real interest: Difference between nominal interest and an amount equal to the loss of purchasing power on the monetary value of the principal during the accounting period. (1993 SNA para. 7.110).

Reappraisals: A change in the estimation of the quantity of (recoverable) subsoil resources due either to new information or technology or price changes. (SEEA-2003 para. 8.32).

Reclassification due to changes in function: The entry of the SEEA asset accounts, that records the change in classification of assets due to changes in function. (SEEA-2003 para. 7.105).

Reclassification due to quality changes: The entry of the SEEA asset accounts that records the change in classification of assets due to quality, e.g. remedied land which becomes useable in production. (SEEA-2003 para. 7.105).

Recreational land and associated surface water: Land that is used as privately owned amenity land, parklands and pleasure grounds and publicly owned parks and recreational areas, together with associated surface water. In SEEA, the categories of land are determined by use. Since recreational land typically has a dual use, it can legitimately be allocated to two headings. In order to have a categorisation where the sum is that of the total available land area, recreational land is shown as an "of which" item under the relevant headings. (1993 SNA, AN.2113; SEEA-2003 para. 7.62).

Recycling: The re-introduction of residual materials into production processes so that it is used as an input in a changed form. (SEEA-2003 para. 3.51).

Reference period: In connection with price or volume indices, the reference period means the period to which the indices relate; it is typically set equal to 100 and it does not necessarily coincide with the "base" period that provides the weights for the indices. (1993 SNA para. [16.16]).

Remedial costs: Costs occurring, when production has already ceased and no provision was made while production was in progress for remedial action to be taken. Examples are the rehabilitation of sites contaminated by past activities; for example, storage of fuels, former landfill and mining sites. (SEEA-2003 paras. 6.59, 6.82).

Rent: See *economic rent* and *resource rent*.

Rental on fixed assets: Amount payable by the user of a fixed asset to its owner, under an operating lease or similar contract, for the right to use that asset in production for a specified period of time. (1993 SNA para. 6.181).

Rents on land: A form of property income; they consist of the amounts paid to a landowner by a tenant for the use of the land. (1993 SNA para. 7.128).

Rents on subsoil assets: A form of property income; they consist of the payments made to the owners of the subsoil assets by institutional units permitting them to extract the subsoil deposits over a specified period. (1993 SNA para. [7.133]).

Research and development: Activity undertaken by a market producer for the purpose of discovering or developing new products, including improved versions or qualities of existing products, or discovering or developing new or more efficient processes of production. (1993 SNA para. 6.142 [6.163]).

Reserves: Resources that are both economically viable to exploit (under current conditions) and known with considerable certainty. They are sometimes grouped into different categories depending on the certainty of knowledge concerning them. See *mineral and energy resources*. (SEEA-2003 para. 8.25).

Resident: An institutional unit that has a centre of economic interest in the economic territory of that country. (1993 SNA para. 4.15 [1.28, 14.8]).

Residuals: The generic term for all unwanted waste materials in solid, liquid and gaseous form resulting from economic activity. (SEEA-2003 para. 2.26).

Resource rent: Value of capital service flows rendered by the natural resources. It is calculated as the difference between the gross operating surplus (or economic rent) and the value of the capital service rendered by the produced asset. (SEEA-2003 paras. 2.151, 7.167, 10.24, Figure 7.3, Box 7.2).

Rest of the world: All non-resident institutional units that enter into transactions with resident units, or have other economic links with resident units. (1993 SNA para. 4.163 [1.14, 14.3]).

Restoration costs: An approach within the maintenance cost approach. The cost of restoring the environment to defined environmental standards. These costs may be "actual" or "hypothetical". (SEEA-2003 paras. 9.50, 9.51, 10.168).

Reuse: The re-introduction of a residual material into a production (or consumption) process so that it is used as an input in its original form. (SEEA-2003 para. 3.51).

Revaluation account: Records the positive or negative holding gains accruing during the accounting period to the owners of financial and non-financial assets and liabilities. (1993 SNA para. 12.63 [1.9]).

Revealed preference pricing methods: Techniques to derive values of environmental services, for which no market prices exist. They comprise market valuation of economic losses, hedonic pricing method and travel costs method. (SEEA-2003 para. 9.75).

Royalties: Term often used to describe either the regular payments made by the lessees of subsoil assets to the owners of the assets (these payments are treated as rents in the SNA) or the payments made by units using processes or producing products covered by patents (these are treated as purchases of services produced by the owners of the patents in the SNA). (1993 SNA paras. 7.87, 7.92).

Satellite accounts: Framework linked to the central accounts, which enables attention to be focussed on a certain field or aspect of economic and social life in the context of national accounts; common examples are satellite accounts for the environment, or tourism, or unpaid household work. (1993 SNA para. 2.246 [21.4], SEEA-2003 para. 2.10).

Saving: Disposable income less final consumption expenditure (or adjusted disposable income less actual final consumption), in both cases after taking account of an adjustment for pension funds; saving is an important aggregate which can be calculated for each institutional sector or for the whole economy. (1993 SNA para. 9.17 [1.10, 9.2, 9.19]).

Secondary activity: Activity carried out within a single producer unit in addition to the principal activity and whose output, like that of the principal activity, must be suitable for delivery outside the producer unit. (1993 SNA para. 5.8 [15.16]).

Semi-natural managed forests: Forests in which management has substantially altered the structure and ecological processes but in which growth is still mainly a natural process with no regular and continuous human intervention. (SEEA-2003 para. 8.158).

Services: Outputs produced to order and which cannot be traded separately from their production; ownership rights cannot be established over services and by the time their production is completed they must have been provided to the consumers; however as an exception to this rule there is a group of industries, generally classified as service industries, some of whose outputs have characteristics of goods, i.e. those concerned with the provision, storage, communication and dissemination of information, advice and entertainment in the broadest sense of those terms; the products of these industries, where ownership rights can be established, may be classified either as goods or services depending on the medium by which these outputs are supplied. (1993 SNA para. 6.8 [6.13]).

Specific taxes: In the environmental protection expenditure account "specific taxes" designate a sub-set of taxes that contribute to the financing of environmental protection. The revenue from specific taxes is regarded as being earmarked for environmental protection. (SEEA-2003 para. 6.23).

Speculative reserves: Estimates of minerals or metals which have not been positively identified but which, based on previous geological experience, it is reasonable to expect to discover in the future. (SEEA-2003 para. 8.25).

Standard river unit: A river stretch of one kilometre with a water flow of one cubic metre per second. (SEEA-2003 para. 8.128).

Standing volume: The volume of standing trees, living or dead, above stump and measured over bark to the top. Includes all trees regardless of diameter, tops of stems, large branches and dead trees lying on the ground which can still be used for fibre or fuel. Excludes small branches, twigs and foliage. (SEEA-2003 para. 8.179).

Stated preference pricing methods: A set of pricing methods where people are asked how much they would agree to pay for avoiding a degradation of the environment (or alternatively how much they would ask as a compensation for the degradation). (SEEA-2003 para. 9.90).

Strong sustainability: Requires that all forms of capital must be maintained intact independent of one another. The implicit assumption is that different forms of capital are mainly complementary; that is, all forms are generally necessary for any form to be of value. Produced capital used in harvesting and processing timber, for example, is of no value in the absence of stocks of timber to harvest. (SEEA-2003 para. 1.27).

Structural adjustment costs: Cover the costs associated with the reduction of activities or complete abstention as well as the changes in production and consumption patterns. These costs can normally only be estimated by modelling or by assumption. (SEEA-2003 para. 9.36).

Stumpage price: The price paid by the feller to the owner of the forest for standing timber. (SEEA-2003 para. 7.253).

Stumpage value method (for standing timber valuation): A simplified net present value method where the value of the stock is obtained by multiplying the current volume of standing timber by its stumpage price, assuming the rate of discount is equal to the natural growth rate. (SEEA-2003 para. 7.260).

Subsidies on production - other: Subsidies, except subsidies on products, which resident enterprises may receive as a consequence of engaging in production (e.g. subsidies on payroll or workforce or subsidies to reduce pollution). (1993 SNA para. 7.79).

Subsidies on products - other: Subsidies other than export or import subsidies on goods or services produced as the outputs of resident enterprises that become payable as a result of the production, sale, transfer, leasing or delivery of those goods or services, or as a result of their use for own consumption or own capital formation; there are three broad categories: (a) subsidies on products used domestically, (b) losses of government trading organisations, and (c) subsidies to public corporations and quasi-corporations. (1993 SNA para. 7.78).

Subsidies to reduce pollution: Subsidies intended to cover some or all of the costs of additional processing undertaken to reduce or eliminate the discharge of pollutants into the environment. (1993 SNA para. 7.79).

Subsoil assets: Proven reserves of mineral deposits located on or below the earth's surface that are economically exploitable, given current technology and relative prices. (1993 SNA, AN.212, para. 13.59 [12.15]).

Supply and use tables

In the SEEA-2003: Matrices in physical and monetary units that record the flows of ecosystem inputs, natural resources, products and residuals according to their origin (environment, domestic industries and imports) and their destination (intermediate or final uses, exports and the environment). (SEEA-2003 para. 2.50).

In the 1993 SNA: Matrices that record how supplies of different kinds of goods and services originate from domestic industries and imports and how those supplies are allocated between various intermediate or final uses, including exports. (1993 SNA para. 1.16 [15.1])

Sustainable catch: Number (weight) of fish in a stock that can be taken by fishing without reducing the stock biomass from year to year, assuming that environmental conditions remain the same. Different levels of sustainable catch exist for different stock sizes. (SEEA-2003 para. 7.279; FAO).

Sustainable national income: Maximum income for a given year that can be sustained with the technology of that year, given a specified standard for environmental sustainability, without assuming technological development except in respect of non-renewable resources. (SEEA-2003 para. 10.203).

System of National Accounts (SNA): Consists of a coherent, consistent and integrated set of macroeconomic accounts, balance sheets and tables based on a set of internationally agreed concepts, definitions, classifications and accounting rules. (1993 SNA para. 1.1).

Tangible fixed assets: Non-financial produced assets that consist of dwellings, other buildings and structures, machinery and equipment and cultivated assets. (1993 SNA, AN.111).

Tangible non-produced assets: Natural assets - land, subsoil assets, non cultivated biological resources and water resources - over which ownership may be established and transferred. (1993 SNA, AN.21, para. 13.18 [13.53]).

Taxes: Compulsory, unrequited payments, in cash or in kind, made by institutional units to government units; they are described as unrequited because the government provides nothing in return to the individual unit making the payment, although governments may use the funds raised in taxes to provide goods or services to other units, either individually or collectively, or to the community as a whole. (1993 SNA paras. 7.48, 8.43).

Taxes on pollution: Taxes levied on the emission or discharge into the environment of noxious gases, liquids or other harmful substances; they do not include payments made for the collection and disposal of waste or noxious substances by public authorities. (1993 SNA para. 7.70).

Taxes on production and imports: Taxes payable on goods and services when they are produced, delivered, sold, transferred or otherwise disposed of by their producers plus taxes and duties on imports that become payable when goods enter the economic territory by crossing the frontier or when services are delivered to resident units by non-resident units; they also include other taxes on production, which consist mainly of taxes on the ownership or use of land, buildings or other assets used in production or on the labour employed, or compensation of employees paid. (1993 SNA para. 7.49).

Taxes on products: Taxes on goods and services, excluding VAT, import and export taxes, that become payable as a result of the production, sale, transfer, leasing or delivery of those goods or services, or as a result of their use for own consumption or own capital formation. (1993 SNA paras. 7.69, 15.47).

Terminal costs: Costs incurred to prevent environmental problems when production ceases (decommissioning of nuclear power plants, final storage of nuclear waste, sealing of landfills etc) These costs should be anticipated during the production periods prior to closure and provision made for them to be met during the life of the asset. (SEEA-2003 para. 6.59).

Total allowable catch (TAC): Total catch allowed to be taken from a resource in a specified period (usually a year), as defined in the management plan. The TAC may be allocated to the stakeholders in the form of quotas as specific quantities or proportions. (FAO).

Total (domestic) material input: Sum of direct material input and unused domestic extraction. (SEEA-2003 para. 3.199).

Total domestic output (TDO): The sum of direct material output and disposal of unused domestic extraction. This indicator represents the total quantity of material outputs to the environment released on the national territory by economic activity. (SEEA-2003 para. 3.202).

Total economy: All the institutional units which are resident in the economic territory of a country. (1993 SNA para. 2.22).

Total material consumption (TMC): An indicator that measures the total primary material requirement associated with domestic consumption activities. TMC equals total material requirement minus exports and their hidden flows. (SEEA-2003 para. 3.206).

Total material output (TMO): The sum of total domestic output and exports. It measures the total amount of material that leaves the economy. (SEEA-2003 para. 3.204).

Total material requirement (TMR): This indicator includes, in addition to domestic material input, the upstream hidden material flows which are associated with imports and predominantly burden the environment in other countries. It measures the total "material base" of an economy; that is, the total primary resource requirements of the production activities. Adding these upstream flows converts imports into their "primary resource extraction equivalent". (SEEA-2003 para. 3.200).

Transaction: Economic flow that is an interaction between institutional units by mutual agreement or an action within an institutional unit that it is analytically useful to treat like a transaction, often because the unit is operating in two different capacities. (1993 SNA para. 3.12).

Transactions account: Shows, for a given transaction or group of transactions (for example, interest), resources and uses for each sector (or industry if relevant) engaged in this type of transaction, but it does not show direct relations between transacting sectors. (1993 SNA para. 2.152).

Transfer: Transaction in which one institutional unit provides a good, service or asset to another unit without receiving from the latter any good, service or asset in return as counterpart. (1993 SNA paras. 8.3, 8.27).

Travel cost method: A revealed preference pricing method that seeks to estimate a money value on the basis of the amount that people actually pay (in money and time) to gain access to beautiful sites, wilderness and so on, or to avoid various forms of damage and degradation. (SEEA-2003 para. 9.86).

Uncompensated seizures: Occur when governments or other institutional units take possession of the assets of other institutional units, including non-resident units, without full compensation for reasons other than the payment of taxes, fines, or similar levies. (1993 SNA para. 12.38).

Unforeseen obsolescence: Arises when the amount included in consumption of fixed capital for an asset's normally expected obsolescence falls short of the amount required to cover its actual obsolescence. (1993 SNA para. 12.43).

Unused extraction: Materials which are extracted by economic activities but that do not normally serve as input for production or consumption activities (e.g. mining overburden). They are not used for further processing and are usually without economic value but accounted for as hidden flows in material flow accounts. (SEEA-2003 para. 3.199).

Use benefits: Benefits that include both direct and indirect benefits. Use benefits also include option and bequest benefits. In addition to these use benefits, an environmental entity may simply have an existence benefit. (SEEA-2003 para. 7.36).

Value added tax (VAT): Tax on products collected in stages by enterprises; it is a wide-ranging tax usually designed to cover most or all goods and services but producers are obliged to pay to government only the difference between the VAT on their sales and the VAT on their purchases for intermediate consumption or capital formation, while VAT is not usually charged on sales to non-residents (i.e. exports). (1993 SNA paras. 6.207, 6.208 [15.47]).

Virtual population analysis: Method used by biologists to assess the physical data on stocks of fish. It employs data on catches from different cohorts of the same stock, together with data on catch per unit effort. (SEEA-2003 para. 8.283).

Water body: Mass of water distinct from other masses of water. (SEEA-2003 para. 5.46).

Water resources:

In the SEEA-2003: The water found in fresh and brackish surface water and groundwater bodies within the economic territory. In the case of surface water, the volume in artificial water bodies is included in addition to that in natural water bodies. The water of the oceans and open seas is excluded on the grounds that the volumes involved are so enormous as to make any stock measure meaningless and that extraction for human use has no measurable impact on them. (SEEA-2003 para. 7.47 EA.13).

In the 1993 SNA: Aquifers and other groundwater resources to the extent that their scarcity leads to the enforcement of ownership and/or use rights, market valuation and some measure of economic control. (1993 SNA, AN.214).

Weak sustainability: Assumption that all forms of capital are more or less substitutes for one another; seeks to maintain from year-to-year the per capita income generated from the total capital stock available to a nation. It allows for the depletion or degradation of natural resources, so long as such depletion is offset by increases in the stocks of other forms of capital. (SEEA-2003 para. 1.27).

Wooded land and associated surface water: Forested land and other wooded land. Forested land is defined as land under cultivated or non-cultivated stands of trees of a size of more than 0.5 hectares with crown cover of more than 10 per cent and on which trees are able to grow to a height of 5 metres or more at maturity. Other wooded land is defined as land either with a tree crown cover of 5-10 per cent of trees able to reach a minimum height of 5 metres or with a crown cover of more than 10 per cent of trees not able to reach a height of 5 metres. (SEEA-2003 paras. 7.67, 8.151, EA.23).

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