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Session on Valuation

Draft Chapter 5

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Note to the reader:
This chapter is work in progress and terminology is not yet harmonised.
It is advisable to first read the Chapter 5 Issues paper, which provides summary conclusions and helps navigating through the chapter 5 text.

Chapter 5: Valuation – Version of 28 October 1999

1 Introduction

This chapter addresses the issue of valuation of environmental goods and services and of environmental assets, based upon, and extending on, the aspects already addressed in the previous chapters.

1.1 Rationale and potential of satellite accounts for environmental valuation

1. Environmental accounts are national accounting systems extended to include both monetary and non-monetary information on the state of the environment and on interactions (e.g. pressures) between economy and environment. Following the modular structure as set out in chapter 1, the development of physical environmental accounts is treated at length in chapters 2 and 3, as is, in chapters 2 and 4, the identification of the monetary elements in the standard national accounts that are of particular importance from a point of view of integrating the environment and the economy.

2. Chapter 5 focuses on the question of 'putting prices' on environmental assets, on services provided by the environment and on changes in the quality of environmental stocks and flows that are outside the production and asset boundaries of the SNA. That is, the focus is on putting monetary values on elements or characteristics of the environment that do not normally have exchange values or (market) prices. Such money values can be obtained using various valuation methods that are reviewed in this chapter. In accounting, the focus is not only on obtaining such values but also on the best places to 'impute' them in a satellite account and on following these values through the satellite account's structure.

3. The valuation of and accounting for depletion of non-produced economic assets (e.g. sub-soil assets) is less controversial and is only mentioned in passing in this chapter for the time being (see chapter 2 for more details).

4. Valuation of the interactions between the economy and the environment in expanded satellite accounts is important for the same reasons valuation in economic accounting is important - for objective scorekeeping and management. In conventional accounts, scorekeeping involves measuring the progress and performance of the economy with respect to economic development. The accounts reveal the composition of and contributors to growth and the interrelationships among measures, such as GDP, the conventional measure of output, and other economic trends such as unemployment. Expanding the accounts to reflect not just economic but also environmental measures will allow better measurement of a nation's performance regarding sustainable development.

5. In addition to their direct functions of scorekeeping and management, the information provided by economic accounts also contributes to forecasts of future performance by revealing relationships among economic trends, activities, and sectors. The accounts inform the construction of models that can be used to forecast the future impacts of various scenarios. Expanding the information provided by the accounts will allow expanded and improved scenario modelling. Indeed, while the information provided by the accounts will inform policymaking, the identification of sustainable development goals and the establishment of policies toward those goals cannot take place solely in descriptive accounts, which is only one step in the policy making process. Analysts must use the information to consider alternative scenarios for the future; the proper course is decided through the entire policy making process. The uses of the accounts in models and the

institutional arrangements and processes necessary for policymaking are discussed in later sections of this chapter and in Chapter 6, Applications.

6. Environmental accounting is an information tool that is supposed to assist in achieving sustainable development. The physical accounts set out in chapters 2 and 3 and the monetary accounts set out in chapters 2 and 4 go a long way in providing the information needed for this. While physical data are useful, especially for revealing detail about specific activities or resources, monetary estimates provide a common numeraire essential for comparison across different activities or goods and decisions about appropriate policy. However, for a government agency to compile such environmental adjustments is difficult, for various reasons. Results of valuation must be meaningful and of acceptable quality and reliability. Given conceptual and practical difficulties with the valuation of many environmental stocks and flows, this condition is currently not met. Some statistics agencies have come to the conclusion that, at the time being and within the limits of the usual standards for quality of official statistics, the physical and monetary accounts as set out in chapters 2 to 4 are all they can contribute for achieving this purpose, without impairing their credibility.

7. In the past, expectations by environmental NGOs, by the public and by policy makers have tended to focus on 'pricing the environment' and on 'adjusting' national accounts aggregates and researchers have compiled a variety of 'environmentally adjusted' macro-economic aggregates. The SEEA introduces a clear distinction between adjusted national accounts aggregates as a result of accounting which refer to the present 'real' economy ('green GDP' type aggregates such as EDP2 or genuine savings) on the one hand and approaches to calculate aggregates of the type 'sustainable national income' ('greened economy GDP') which refer to scenarios for future (hypothetical) economies based on modelling on the other hand. However, with the latter approach it is possible to also compile 'greened economy GDPs' for past years. Both approaches have their strengths and weaknesses.

8. An objective of valuation along the 'greened economy GDP' approach is to 'cost sustainability', i.e. to provide a money estimate of the costs to society for reaching sustainability. This notion entails several issues. First, the typical mix of unsustainability consists of external effects, public goods, a global context, slow processes, complex systems and uncertainty. Hence, sustainable development is likely to be achieved by a restructuring process of the entire society and the full internalisation of sustainability problems would cause structural changes of the (market) system as described by the SNA.. Second, the time-path of that transition process cannot be anticipated by (scientific) assumptions and (statistical) surveys or estimates. Finally, as the concept of sustainability is not sufficiently operationalised for many areas of concern and as the transition path is uncertain, the end-point of this transition is not well known.

9. This in turn raises the rather basic question of the reference point for valuation. Major decisions often emerge from complex negotiations between parties, interest groups etc., which reflect the preferences of citizens in a rather indirect way. One role of valuation is to inform such negotiation processes. One should however be very clear in the recognition that valuation does not substitute political decisions. In the contrary, in the context of valuation many economic values result from the political setting of sustainability standards and targets. The political decisions are not necessarily identical with the sum of individual preferences nor do they necessarily satisfy any theoretical economic or welfare optimum. However, political decisions define or determine economic values in a very real sense. If, for example, a reduction goal for CO_2 has been defined, the scarcity of rights to emit CO_2 increases and their 'price' will increase. Implicitly, this price reaction indicates the economic value of an intact climate, based on social, rather than individual, preferences. Given the

normative elements present in most valuation methods an important aspect of the different valuation methods is thus whether the values generated are ‘constructed’ or ‘discovered’.

10. The contribution of science / statistics to these decision processes lies in a user oriented evaluation of the existing knowledge in order to guarantee rationality in decisions and procedures. This is obviously less ambitious than a strategy of optimisation. Having accepted the complexity of the problem it seems however to be the only practical and realistic way to proceed.

11. Given the macro-economic perspective in environmental accounting, the issue of indirect effects is important. These indirect effects are firstly connected with technical changes. Secondly they reflect structural changes within the economy, which are partly necessary to achieve the standards (changes in patterns of production or consumption) and partly can enable the economy to adapt to new environmental constraints with less or without economic losses (‘no regrets’ and ‘double dividend’ policies).

12. The calculation of environmental adjustments of GDP, that has to take place on a macro-economic level, is not merely a task for statisticians or accountants. Macro-econometric models may be required to construct realistic scenarios of future (or, indeed, past) situations or developments. In many countries such modelling does not belong to the catalogue of tasks of the institutions responsible for compiling the national accounts. Therefore, in order to ensure proper co-operation between statisticians and model constructors (using statistical facts for their simulations of the future) appropriate institutional and organisational arrangements are necessary.

13. In economics, the valuation of the environment is based on the fundamental issues of externalities and of scarcity. In simple terms the issue of externalities rests on the assumption that economic costs are associated with the (unpriced or underpriced) use of the environment in consumption or production in the sense that such uses suppress other possible uses or damage or restrict other economic assets or production or consumption possibilities. In economics, the existence of externalities is assumed to give rise to inefficiencies because the unpriced (yet scarce) components or characteristics of the environment will –assuming rational behaviour of economic agents – be overexploited, leading to society-wide costs that are higher than the benefits derived from this overexploitation.

14. Since the publication of the interim version of the SEEA progress has been made towards ‘pricing the environment’ along several lines. Research has made progress in refining valuation methods. While many valuation methods have originally been developed and used in rather specific and localised conditions, research has moved some way towards developing methods and procedures for aggregating the values such obtained to higher levels (for example cost-benefit analysis of whole policy packages or the method of benefits transfer). In policy preparation and also on the legal floor, the use of cost-effectiveness and cost-benefit methods is becoming more widespread which, in the longer run, will provide more of the basic data needed for valuation satellite accounts. Finally, also in statistics and statistics-related research valuable conceptual insights and practical experience has been gained on the use of valuation methods, their data requirements and their costs of compilation. The conclusions from statistics-related research are less encouraging as regards current feasibility of large-scale valuation and the calculation of environmentally adjusted national accounts aggregates (e.g. Japan, Germany, the Netherlands). Primary data sources are still lacking and resource are currently very high but further progress in these areas may be expected for the future.

15. For all these reasons, this manual - while acknowledging the substantial limitations at the time being - sets out to review the valuation methods available, the progress made since the publication of the interim version of the SEEA, the data requirements and sources for valuation and the meaning, potential and reliability of compiling, in a satellite accounts context, 'environmentally adjusted' national aggregates.

16. Several methods are available for valuing unpriced environmental services and assets. This chapter will review these methods. Unfortunately, none of these methods is ideal and several drawbacks must be noted when these methods are used at the sectoral and national scale and under the consistency requirements of the national accounts. These drawbacks refer to issues such as coverage (some methods can only be used to value 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 to obtain and interpret the basic data (physical and monetary) needed for these valuation methods.

17. Conceptual difficulties persist. For example, the idea of unpriced services provided by the environment refers to the overall 'value' of these services. This is linked with the concept of externalities insofar as the total 'value' of the free services provided by the environment (life-support functions such as unpolluted air, water and food, or recreation and amenities) is impaired by externalities. In other words, the capacity of the environment (as an asset) to provide these free services is reduced. Conceptually, however, it makes a difference whether valuation attempts to measure and incorporate the full value of environmental assets and the services provided by these or only the part that is 'economically scarce' and affected by (positive or negative) externalities.

18. Valuation of environmental goods and services is often understood as a purely technical question as part of economic theory. However, for the design and implementation of valuation concepts in a national accounts context decisions and priorities are necessary based on axiomatic settings, the trade-off between (different) theoretical concepts and objectives as well as the possibilities and limitations of practical realisation.

19. As discussed in Chapters 2 and 3 and above, physical data is necessary to reveal the detailed processes taking place with respect to natural resources and environmental assets, and therefore essential for monitoring the progress of focused regulatory or conservation policies and for modelling the impacts of proposed policies or actions. In addition to this, monetary estimates can provide a common numeraire essential for comparison across different activities or goods and decisions about appropriate policy. The best example of the need for valuation is where more than one environmental issue must be addressed. Given limited resources, competing issues must be prioritised; the ideal approach is to examine and compare - in the same units - the costs and benefits of each alternative policy to identify the approach with the best results for the least expense. Cost-benefit analysis could, in the ideal case, show the appropriate allocation of resources.

20. Unfortunately, given the lack of information and the uncertainty often associated with environmental issues, the valuation of both the costs and benefits of environmental issues is often infeasible, 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 themselves, that do not have observable market prices. In the absence of observable and objective monetary reflections of value,

prioritisation must occur through some other medium. The most likely and available method is the political process itself. Voter apathy, the influence of lobbies, and political manoeuvring may somewhat diminish the objectivity of the preferences revealed through political negotiation; nevertheless, preferences can be ranked according to the concerns revealed through this process. Once done, the appropriate response may be identified through a variant of cost-benefit analysis known as cost-effectiveness analysis. This approach identifies the most cost-efficient policies that will address a pre-specified priority to a pre-specified standard of success. The advantage over cost-benefit analysis is that this approach requires monetary valuation not of the natural resource or environmental asset itself, but of the proposed responses. Of course, these activities may also involve environmental costs that cannot be easily measured; again, the political process may suggest whether these costs are perceived to exceed the benefits and whether the activity should be undertaken.

21. The main purpose of valuation is the reduction of complexity. Valuation allows to compare 'unpriced' goods and services with goods and services that have a market value, permits the aggregation of different environmental goods and services, allows to compare costs and benefits and supports the internalisation of externalities into monetary accounting. As said above, the ideal case would be a cost-benefit-type approach, where both the cost and the benefits side are valued. Given the current limitations of resources and basic data, practitioners will often have to revert to cost-effectiveness-type approaches, accepting that the benefits gained or lost pass unnoticed. Partial accounts of both costs and benefits are conceivable although the estimates of costs and benefits will rarely be reconcilable. In a policy context, such partial accounts may nonetheless be extremely useful, giving rise to what could be termed 'multi-criteria decision support'.

22. For this manual, the reference system is the SNA. This means that the results of any valuation method must be checked for their applicability, and place, in a framework based on national accounts principles. The following questions must be addressed for each valuation method (and indeed each value derived from these):

1. are the values obtained close to the concept of exchange value (market prices) prevailing in the SNA (e.g. inclusion of consumer surplus in willingness-to-pay results)?
2. do these values overlap with, or are they already included in, SNA values? For example, some applications of the hedonic price method identify values of environmental characteristics that are already incorporated in SNA values, e.g. prices of real estates; the same may hold for willingness-to-pay studies in that they capture values already included in SNA (e.g. as non-market output). Also, a clear separation of values based on actual transactions versus 'hypothetical' transactions or values must be made.
3. do they refer to the period of time and to the geographical boundaries that prevail in the SNA (e.g. data derived from cost-benefit or willingness-to-pay studies may refer to the lifetime of a project rather than a year)?
4. do the values relate to production or consumption or assets as described in a country's national accounts (e.g. domestic externalities of domestic production processes)?
5. do the values refer to stocks (value of assets) or to flows (value of services derived from assets)?

23. With regard to question 1) above it must be noted that national accounts themselves are not entirely based on market prices. Several levels of 'closeness' to actual market values can be distinguished. Valuation based on the cost of production (for non-market output or additions to inventories prior to sale), use of market prices of similar products (e.g. in the case of the imputed rents for owner-occupied dwellings) or calculated values (e.g. the consumption of fixed capital or the net present value for economic assets) may serve to illustrate this. But the inclusion of monetary values of environmental services and assets requires to

incorporate imputed values in a national accounts-type framework. For this to be possible and meaningful, the nature of these values must be clearly understood.

24. Therefore, applied valuation is interpreted as a complex process that rests on inputs from science and from policy decisions that in turn are based on negotiations between parts of the society with conflicting interests. The requirements for suitable data in connection with the various valuation methods are considerable. For example, avoidance cost curves (= direct cost calculations based on statistical processing) need data input from a technical and economic side. This is partly possible in those cases where corresponding information systems are already available (energy, air emissions). In the majority of problems it would however be an illusion to expect ready-made basic data. Thus it is necessary to keep this problem in mind when designing the valuation concepts to be used in conjunction with annual accounts.

25. For the time being this manual recommends to start with whatever is available and with a focus on the most important problems in each country. Given the limitations in many countries it is advisable to present valuation results in an experimental satellite accounts context quite separate from the core national accounts. There is evidence that macro-econometric models are relatively cost-effective tools for the next steps in this field. Due to these limitations internationally comparable and generally agreed results cannot be expected for the near future. Further progress in the institutional settings, in research and in the availability of basic data is both necessary and can be expected for the future.

26. The principal objectives for setting up satellite accounts with environmental valuation are:

- consistency with accounting principles in terms of valuation methods used and in terms of periodicity (one year) and coverage (economic territory, domestic economy),
- consistency as far as possible with economic theory or theories,
- availability of the basic data needed,
- relevance of the results for decision making,
- appropriateness of the results for the environmental issues covered and
- comprehensiveness in coverage of phenomena and values.

27. Greening the national accounts by including environmental assets and services therefore has to be seen as a process in which valuation plays an essential part but is not at all sufficient for success. Equally important are issues of capacity building and agenda setting, the organisational settings that allow for efficient co-operation with science and policy makers and the building-up of stocks of basic data. As the regular generation of the basic data needed for valuation is resource-intensive, such data generation would preferably be justified by uses in addition to those in environmental accounting alone. Chapter 6 elaborates on these points.

1.2 Scope, coverage, role in decision processes

28. Accounting can and should not be an isolated activity and it is important to be careful in the creation of wrong expectations in the public. It is recommended to avoid the announcement of an EDP or a sustainable income as a "true" measure of growth before the results have been subject to external review. Insofar as the logic of accounting allows only specific calculations to be made, this chapter suggests specifying the interfaces between accounting and other information providers (e.g. modellers). Instead of environmental valuation within the accounts (which may not be meaningful or reliable in some cases) a very close co-operation between (ex-post) accounting and (ex-ante) modelling is explored as a way to respond to the demand by policy, research and the public. See also André Vanoli's work with regard to the separation between ex-post and ex-ante modelling. Since this co-operation is not at all self-evident it is important to make appropriate institutional arrangements (see section 3.3).

1.2.1 Which answers for which questions?

29. There are different perspectives of what 'environmentally adjusted' satellites to national accounts could present. These refer to:

1. Adjustments in balance sheets, estimates of national wealth and savings
2. Adjustments to current accounts of production, income distribution and consumption
3. Future paths of national income under sustainability conditions

30. The following points should be emphasised:

1. The (perhaps important) question of an indicator, based on historical data for a current or past year, of a nation's "real income" (taking account of natural asset depletion and/or environmental degradation), is - both theoretically and in terms of estimation procedures - quite separate from the question of an estimation of prospects for FUTURE performance, which is conceptually close to the idea of estimating a 'sustainable' national income.
2. The question of the usefulness or not of monetary valuations depends a great deal on the PURPOSE, e.g. policy consideration, decision issues, time frame, scales of aggregation, etc.
3. The micro-macro perspective is important in valuation. Simply adding micro-economic costs and benefits to arrive at a macro-economic figure is often seriously misleading. This is best illustrated by the controversies over the macro-economic effects of environmental taxation.

1.2.2 Indicators of natural wealth as a component of national wealth

31. A basic question centres on the maintenance or loss (and rate of loss) of natural wealth and whether investment in other assets compensates. Balance sheet data include the effect of natural change as well as economic activity and present a stock perspective. Natural assets that are currently measured are 'economic assets' and wealth is the value of future income. It seems feasible to extend the scope beyond the SNA93 boundary of economic assets. Resources other than proved reserves, or forest that is currently remote could be valued. Consumptive uses of resources outside the market economy – subsistence agriculture, hunting, fishing, etc., can also be valued, where they are important (even within the SNA production boundary).

1.2.3 Descriptive measure: EDP

32. A common interpretation of a "green NDP", i.e. an EDP, is that the national accounts should include the impact on the environment caused by the economic activities that are registered in the accounts. These impacts include the effects on non-SNA flows and assets in the current accounting period, and effects on both SNA and non-SNA flows and assets in the future. To do this, prices for non-priced environmental flows and assets must be imputed. A number of methods for doing this have been suggested. They are described in section 2.2 of this chapter. A practical approach is to approximate these marginal utilities by the costs for avoiding the damages on the environment. The method for doing this is described in section 2.3.

1.2.4 Optimising measure: SNI

33. The question of "greening" the national accounts has, over the years, been closely associated with the notion of estimating a "sustainable national income" (SNI). There has been a tendency to assume that an "environmentally adjusted national income figure" means, automatically, an "SNI".

34. An "SNI" is the level of national income that can be sustained indefinitely into the future. Thus it is an estimate about what is or might become feasible in the future, making the assumption that natural resource exploitation and environmental degradation are controlled so that the productive capacity of the economy (human and produced capital) together with the environment (natural capital) is permanently renewed and maintained.

35. The conditions for maintenance of natural resources and environmental quality are often referred to as 'sustainability standards'. Estimates of environmental carrying capacity (and hence 'true' sustainability standards) can be relatively easily found for fields such as fish catch, forest harvesting or quantitative water use (although the need for regional, seasonal or species detail should be recognised) but are difficult to obtain for most other areas. Hence, in practice, surrogate standards are often used for both EDP and SNI calculations, which are derived from international agreements or national policy plans.

36. When non-sustainability of the current economic structure is assumed, the issue of finding appropriate standards is further complicated by the need to recognise – in a dynamic perspective - the issue of a 'transition path towards sustainability', i.e. the need to develop standards (and adapt them over time) that will move the economy (or certain activities) towards a sustainable state. A simple example for this is over-fishing, which may require setting annual extraction at a level that ensures recovery of the fish population. It is essential to distinguish, among environmental standards, flow and stock standards. Stock standards relate to environmental assets (such as water quality standards, biodiversity targets, or CO_2 concentrations in the atmosphere) and must be converted into current flow standards that can be applied to economic activity (such as rates of pollution, or deforestation) to fit into annual accounting frameworks. Then, on this basis, estimates can be made of economic performance prospects for a national economy, while respecting environmental standards.

37. For empirical and policy-related purposes, the requirements of maintaining the natural resource and environmental waste absorption and life-support capacities is best approached through defining norms relating to maintenance of key "environmental functions". Essentially this is done through exploitation of environmental information, organised with reference to economy-environmental interface categories, namely environmental "pressure" indicators relative to estimates of environmental carrying capacities. The NAMEA information framework is an example of such a way of organising environmental information so as to get an

‘economy-environment interface’. A NAMEA can directly relate economic and environmental information without the need for monetary valuation.

38. If a complete set of standards sufficient to assure long-run sustainability were specified, and estimations were made of future economic prospects including national income prospects achievable while fully respecting this set, we could speak of an estimate for a sustainable national income. To achieve such a measure, calculations should be made for performance prospects subject to a complete set of standards and full compliance with these. As this is rarely possible in practice, the results are scenario estimates for national income of an economy on a time-bound transition path towards sustainability, which cannot, in a strict sense, be termed ‘sustainable income’.

39. This is an application of the "cost-effectiveness" approach, where a set of constraints or standards are identified, and the economic costs associated with respect of these standards are estimated, avoiding the need to value the benefits associated with achieving these standards. The cost-effectiveness concept is applied at a whole-economy level, where the model takes into account the inter-dependent adjustments between sectors. Explicit hypotheses are made concerning technological prospects for pollution abatement and improved resource efficiency, consumption patterns, and the required environmental standards. In this way the scenario modelling approach is interfaced with various dimensions of policy debate. It should be noted that national accounts, and thus satellite extensions of them, focus on describing current or past activities, not on predicting or modelling future situations. The use of descriptive accounts in predictive models is therefore generally seen as an application of the accounts (see chapter 6) rather than belonging to the accounts themselves.

Economic impact of change in resource-based industries, regional development, community well-being and community sustainability measures

40. National measures of resource stock value and depletion and degradation should be a 'sum of regional accounts', although this is often not practical (depletion as a national aggregate is probably not a very useful number, anyway, unless a nation is heavily depending on resource use). Many of the issues around natural resource use are 'local' issues - requiring regional accounts, or regional detail in aggregate accounts. The impact of resource depletion on a one-industry region isn't quite captured in a national depletion measure based on rent, which is based on assumptions that labour and capital are mobile.

41. The valuation of environmental services and assets in a satellite account is restricted to past and current activities. The borderline between past and future as applied in these accounts is thus important. The following should be emphasised: the calculation of (present) consumption of fixed capital, or of depletion, for example, is necessarily based on assumptions about the future. Similarly, a valuation of externalities of current activities requires to reallocate future effects (e.g. damages from climate changes in the year 2050) to activities in the past or the present.

2. Valuation and evaluation processes

42. Section 2 provides a collection, description and appraisal of the different valuation methods. For the appraisal of each method, the following aspects are analysed:

1. Situations/decisions for which the tool/method is suitable to use. How each tool can be used to support decision processes.
2. Limitations of scope (which environmental phenomena the method can or cannot cover, at which geographical scale, etc.)
3. Suitability of the tool in national accounting: do results relate to stocks or flows, do they relate to the current accounting period or not, are the issues inside or outside the national accounts (e.g. losses in agriculture are ‘already captured’)
4. Practical aspects/limitations: data requirements and resource needs, specific problems (e.g. corrections for consumer surplus or income-level-bias in willingness-to-pay methods, stability of results over time, difficulty in predicting (hypothetical/future) costs, interpretation of changes of values over time in terms of price and volume changes, etc.)
5. What is the ‘economic’ entity the results refer to (e.g. damage or restoration costs often relate to the geographical territory, whereas hypothetical avoidance costs relate to emissions caused by the domestic economy).

2.1 Overview over methods - ways and means of "pricing" the environment

2.1.1. Pricing the environment as an operation of comparison

43. The underlying principle for environmental valuation in monetary terms is that although we cannot introduce all ecological goods and services into actual markets, it is nevertheless possible to extrapolate in various ways from actual market transactions so as to get an estimate in money terms of the value of some environmental good, or the cost of some environmental harm. Environmental good or damage may be valued in terms of its positive or negative impact (direct or indirect) on economic activity and marketed products, for example the production of goods having a market price, or it may be assessed on the basis of substitute or complementary products that do have a price.

44. During the industrial period, material progress has been seen as synonymous with the augmentation of the quantity and quality of manufactured outputs. Correspondingly, value in economics has meant, foremost and sometimes exclusively, the value of produced goods and services. The services of nature such as availability of air, water or land of an acceptable quality were obtained ‘free’.

45. Economics links value to scarcity, and it is necessary to distinguish "use-value" and "exchange value". In places where water is abundant, it is often obtainable free of charge; it is nonetheless a fundamental requirement of human life. Thus valuation is a problem linked on the one hand to costs of access, on the other hand to conflict over access under conditions of scarcity. The scarcity may, in turn, be determined in quantity and quality dimensions (such as limited river flows or aquifer renewal rates, but where the availability of water of qualities adequate for drinking or irrigation is furthermore menaced by rising salinity, bacterial contamination, heavy metals, nitrates, pesticide residues and so on). In all respects, though, the preoccupation

is with human action and human induced change in the natural world, and the possible repercussions of human actions and human-induced change back on (present and future) human society.

46. It is useful to distinguish three main dimensions to the concept of environmental change:

1. It can refer to actual or potential effects to the physical, chemical and biological systems that are required for the possibility of human life and economic activity being sustained over a long period of time.
2. It can refer to the adverse effects of human activity upon the natural world — in the loss of biodiversity, the destruction of habitats and so on.
3. It can refer to the detrimental impact of human activity upon aesthetically and culturally significant landscapes and places and the environment as a source of recreation.

The sources of environmental concern are complex, and these broad categories overlap in various ways.

47. Now that it is admitted that environmental services are finite and can be degraded, the tendency amongst economists is to extend the notion of opportunity cost to the wider environmental domain. Yet we cannot simply presume that perspectives of cost-benefit comparison that work quite well for commercial project appraisal and for analysis of systems of commodity production and exchange (while presuming that environmental conditions remained roughly unchanged), can be successfully transferred to the entire non-produced domains of our planetary life support systems. Careful attention is required to the physical and temporal scales, and to the analysis purposes for which any particular evaluation method and quantitative results may be appropriate.

48. When standard monetary valuation is attempted, the values of environmental goods and services are often separated into use and non-use values. Although no generally agreed categories, for the purposes of the SEEA use and non-use values are defined as follows:

- Use values first of all refer to the <u>actual use values</u> of environmental goods, for example, for recreation. Use values also include the <u>option values</u> that express the preferences that individuals have for an asset or service they might use in future as well as <u>bequest values</u> that signal preferences for preserving an environmental asset or service for others including future generations;
- Non-use values cover only <u>existence values</u> (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.

49. Additional categories of values may be added to the above and the distinction between use and non-use values may have to be drawn differently. Taken all together these constitute the total economic value of the features in question (Pearce & Turner 90). The notion of total economic value can be valuable as a way of signalling the need to broaden the horizons of analysis. But robust quantitative estimates are elusive.

2.1.2. The "supply of" and the "demand for" environmental values

50. In conceptual and operational terms, the valuation of environmental assets and service in money terms can be approached in two distinct ways:

(i) On the "supply side": by estimates of economic costs — that is, the reduction in other opportunities for assuring goods and services provision — that are or might be incurred in ‘supplying’ environmental functions, that is in abating deterioration or repairing damage, or substituting environmental functions, or that might be saved when damage is allowed to occur; and

(ii) On the "demand side": by estimates of the monetary value of the environmental assets and services that are lost, at risk or to be gained— that is, the value of the lost or gained, or potentially improved or deteriorated environmental amenity or service itself.

51. The principle of distinguishing supply side and demand side approaches is to allow distinction of the ‘cost of supply (or substitution)’ of environmental assets and services from the ‘value of demand’ for environmental assets and services, thus avoiding mix-up of values derived for both sides. It should be noted that the two approaches above are not necessarily identical to the cost and benefit categories in cost-benefit analysis. This, because in the SEEA both ‘supply side costs’ and ‘demand side benefits’ are valuation methods and their results are principally (positive) values of environmental assets and services or of (positive or negative) changes in the value of assets or of service flows. In accounting such values may then be treated as cost of production, as ‘imputed’ final consumption expenditure or as additions to, or reductions in, the value of environmental assets. For example, hypothetical avoidance costs, as they have not actually been incurred, can be interpreted as economic benefits (costs saved) whereas the value of a benefit lost can constitute an economic cost, e.g. actual damage costs that occurred. Hence the accounting treatment must be kept completely separate from the act of valuation.

52. The 1993 SEEA attempted to capture these two approaches by using the concepts of ‘costs caused’ and ‘costs borne’ and pointed out that the concepts often refer to different entities and times of recording. For example, pollution that leads to damages in a different country, or damage that originates in past activities or in activities in a foreign country. Nonetheless the two approaches can, at times, be two sides of the same coin so that, assuming an equilibrium situation, the value of a (theoretically: marginal) benefit lost or gained could be used as a proxy for the value of the economic costs saved due to the benefits foregone or resources needed to achieve these benefits. However, several reasons prevent a broad use of this assumption in accounting. Given the substantial shortcomings in basic data and scientific knowledge, the money values of costs or benefits often are not comprehensive and have considerable error margins attached. Moreover, there is little basis to assume an equilibrium situation.

53. The two approaches would in principle be reconcilable by the following sequence of adjustments:

Domestic costs of supply in the current accounting year
- damage/reduction in damage occurring in other countries
- damage/reduction in damage occurring in later accounting years
+damage/reduction in damage occurring domestically due to non-domestic activities
+ damage/reduction in damage occurring due to domestic activity in earlier accounting years
+/- adjustment due to differences in valuation methods
= domestic value of demand or damage value in the current accounting year

While it seems difficult at present to specify values for the different adjustment categories it should be noted that comprehensive damage valuation approaches based on the dose-response approach can, via a set of inter-linked physical accounts, be linked to the causes. It was in principle demonstrated by a recent EU research project (GARPII) that NAMEA-type air emission accounts for a limited set of pollutants can be linked, via geo-referenced emission sources, physical models of translocation of pollutants and (again geo-referenced) ambient concentration models, to estimates of damage. In this way, monetary balances of imported and exported damage costs can be set up.

54. Actual and imputed costs and benefits are distinguished in the SEEA. For actual expenditure/costs the figure IV of the SEEA93 (page 44) explains the various points of appearance in the cycle of environmental deterioration/improvement. These points are useful as they shed light on the kinds of values that can be derived or measured at each point. Figure IV distinguishes:

1. Preventive activities (1) and (2) which represent activities either by the polluting economic actors (1) or by external treatment activities (2) to prevent the pollution from occurring – the corresponding activities and expenditure are described in Chapter 4
2. Residuals and other pressures that reach the environment will be subject to natural assimilation (4) and to restoration activities (3)
3. Insofar as the quality of the environment deteriorated due to present or past pollution or improved due to restoration activities or natural processes this will have impacts on the economy. Negative impacts (repercussions) can be evaded or contained (5) to some extent, leading to changes in behaviour of the population, travel to other sites for recreation etc. Positive impacts will lead to reduced evasion activities.
4. Repercussions that cannot be evaded will lead to negative impacts (damages) on the economy. These may then be actually treated (7) (e.g. water purification, repair of buildings, health expenditure) or welfare losses will occur.

55. An experimental presentation to raise the question of 'additivity' of various valuation methods for an environmental asset:

Stage in the process	**Actual asset and transaction values**	**Imputed asset and transaction values**
Initial situation (opening stock)	None	Value of environmental service/asset?
Prevention (1)	EPE – see chapter 4	Hypothetical avoidance costs
Treatment (2)	EPE – see chapter 4	Hypothetical avoidance costs
Natural assimilation (4)	None	Value of environmental service?
Restoration (3)	EPE – see chapter 4	Environmental improvement/imputed restoration costs
Evasion (5)	Damage costs	None
Damage treatment (7)	Damage costs	Other damage costs
Net change	None	Net improvement or degradation (including revaluation)
Final situation (closing stock)	None	Value of environmental service/asset?

2.1.3. "Supply side" approaches to environmental valuation

56. Examples of approaches to environmental valuation from the "supply side" are:

- Restoration costs (actual or potential) in response to environmental pollution, to maintain or restore rivers and lakes to certain levels of water quality, fishery stock, etc., or actual costs of substituting (lost) environmental services, e.g. to restore buildings or to remedy human health problems due to pollutants.
- Avoidance costs (actual or potential) to avoid environmental damage: e.g. the costs incurred in introducing new technologies to reduce greenhouse gas emissions; traffic calming and noise buffer measures in town; installing catalytic converters; improving safety measures against toxic chemical spills in storage, factory use, and transportation; diverting a road out of a site of special environmental value.

57. The monetary figures obtained with these "supply-side" approaches relate to actual or hypothetical (imputed) expenditures to achieve improvements in environmental quality, to avoid degradations in quality or the substitute or replace environmental services. In the SEEA, the basic data available for, and accounting treatment of, actual and of imputed expenditure is very different. Also, the meaning of restoration costs and avoidance costs is different in accounting terms. Restoration costs refer to a variety of causes, including natural events, domestic economic activities in the past or economic activities in other countries. Avoidance costs refer to the present emissions and to domestic economic activity. For details see section 2.4.

58. It should be clearly seen that such figures do not necessarily provide an estimate of the monetary value of the benefits gained (or the loss forestalled). In general, actual expenditures aimed to "supply" environmental goods and services — that is, investments and expenditures aimed to avoid environmental damage or to restore an environment that has been damaged — do not necessarily correspond closely to all the benefits that are or might be gained. For example, the restoration benefits of forest replanting might be much greater than the costs to a landowner, but captured by other persons over a long period of time.

2.1.4. "Demand-side" approaches to environmental valuation

59. The non-correspondence between costs incurred and benefits obtainable (see also section 2.1.6 below) helps to explain why a lot of effort has gone into devising techniques for inferring the "demand" for environmental benefits from the hypothetical or observed behaviour of individuals in markets, that is, how much they are willing to pay for environmental services or to avoid environmental damage.

60. "Demand-side" approaches involve placing a money value on components of the environment (characterised in quantity and quality terms) or on the services that the environment provides. This requires some way of identifying and describing these benefits and services and changes in environmental quality and quantity affecting the availability of benefits and services. It is common to distinguish two ways of going about the task:

61. One-step approaches supply descriptions of the different changes in environmental quality, usually with the aim of eliciting information on individuals' willingness to pay for improvements or to avoid deterioration. Here the primary difficulty is often with defining the changes (the good or harm) in question. The objects or systems often have many different functions. For example, with water, it is possible to link quality with biological, health or recreational possibilities — is it safe to drink, is it safe to bathe? — and to start with individuals' own estimations of water quality as a starting point. But ecological cycles may also be

important. With issues such as biodiversity — involving, for example, the impact on bird populations of different levels of drainage in wetlands — providing valid yet understandable descriptions can become extremely difficult.

62. Two-step, or "Dose-Response" approaches, by comparison, begin by asking, "what caused the damage?" and develop a description in terms of causes and effects. Frequently, data from the physical and biological sciences are used to link a particular sort of pollution at different levels (the dose) with different levels of physical damage to human, animal and plant communities (the environment's response). Then, going further, a monetary value can be placed on the physical damage, thus furnishing a monetary valuation not just of the environmental damage (or benefit lost) but also linked back to a given dose of pollutant.

63. An example of detailed methodical application of the dose-response approach for placing monetary values on environmental damage is the "ExternE" study funded by the European Commission under the JOULE programme. This research, initiated at the beginning of the 1990s, aims at providing an operational accounting framework for monetary estimates of the externalities associated with the energy supply sector. Initial effort focussed on the coal and nuclear fuel cycles, and then oil and gas fuels, hydroelectricity, and wind power. A first round of methodological considerations and results were reported in six volumes (EUR-1652 ExternE: Externalities of Energy, vols.1-6, 1995). Extensions to further fuel types and implementation work for the 15 EU member states are still ongoing.

64. The Dose-Response approach has the advantage of being a relatively systematic way of approaching the identification of changes in the environment caused by economic activities. But there is nonetheless always the possibility that important environmental functions beneficial to society go unnoticed and that some significant damage effects may be left out (for example, many pollution effects become noticeable only after quite some time).

65. Once benefit and damage categories have been decided, the question is how to attach a monetary figure to them. The most commonly used methods for quantifying environmental benefits from the "demand-side" are the travel cost method, hedonic pricing, and contingent valuation methods (see section 2.2.3 for further description) as well as the use of market and derived prices (as in section 2.2.2).

66. 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 beauty spots, wilderness and so forth, or to avoid various forms of damage and degradation. In effect, the costs that are incurred by visitors to a site are taken as a proxy to calculate the recreation value they place upon that site. This can be the basis for estimates of the significance (in money terms) of damage or loss of availability of the site.

67. **Hedonic Pricing** correlates the environmental good or bad with some actual market item such as houses, so that variations in the price of houses from one locality to another can be correlated with the presence or absence of some desirable or undesirable environmental feature, e.g. a view or ambient noise levels. How much people are willing to pay is then supposed to reflect their preference for the environmental good in question, or their aversion to the bad. In effect, hedonic pricing methods employ a proxy good in the market to estimate individuals' willingness to pay for environmental goods and to avoid environmental damage.

68. **Contingent valuation methods** (CVM), usually conducted through survey or interview of a sample of the interested population(s), present people with hypothetical situations (or, in some cases, simplified "laboratory" choices) designed to elicit statements about what they would be willing to pay (WTP) for preserving a specified environmental feature, or the compensation that they would find acceptable (WTA) in the case of its loss.

69. The travel-cost method and hedonic pricing are revealed preference valuation techniques, which involve deducing a money value on the basis of (a) observed time and money expenditures for goods in some complementary or substitute relation, and (b) underlying hypotheses about "optimising" behaviour. These are sometimes referred to as indirect methods.

70. In the case of CVM, by contrast, the "worth" of environmental features is elicited directly through the questionnaire procedures.

71. Application of these sorts of "demand side" approaches received a strong boost by emergence of legal frameworks, notably in the United States, which have promoted CVM as a basis for deciding compensation for environmental damage due to industrial accident or waste spillage (see NOAA/Arrow et al. 1993). Results from application of such methods become components of environmental cost-benefit analysis, which in its most simple formulations aims at achieving the highest balance of benefits over costs for the project or policy selected (e.g., maximising net present value, or having marginal abatement cost equal to marginal benefit of pollution abatement).

2.1.5 Estimation problems

72. A popular view amongst environmental economists is that it is (relatively) straightforward to make estimates of the economic costs of avoiding particular categories of damage or natural resource depletion; but it is much more speculative to obtain money estimates for the benefits of such action. In fact detailed empirical work on firm-level environmental expenditures and statistics-based sectoral estimations of abatement cost curves (e.g., in the GREENSTAMP project, see the papers collected in the International Journal of Sustainable Development IJSD Vol. No.2, 1998), suggests that cost-side information is very heterogeneous and often somewhat speculative, even for well-defined investment and technology choice situations. So robust "supply-side" valuation information is not as easy to come by as one might like to hope.

73. 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 method (see section 2.1.7 below). Others relate, however, to difficulties of the subject matter. The application of environmental cost-benefit valuation techniques involves the attempt to extend and transpose traditional economic valuation methodology, together with underlying hypotheses about consumer preference formation, substitutability and opportunity cost estimation, and so on, into arenas for which it was not originally devised, namely: (i) extension spatially and materially to the complex non-produced and largely non-commodified "natural environment;" and (ii) extension temporally to the "long term" of ecological change and sustainability concerns.

2.1.6. Bringing together supply-side and demand-side considerations

74. 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 benefits obtained, is an allocatively efficient (Pareto-optimal) level of goods and damages production. This optimisation approach requires money estimates of the "marginal benefits" and the "marginal costs" of the environmental protection or enhancement action.

75. Quite apart from estimation difficulties (see above), it is important to note that cost and benefit considerations usually arise separately and are not automatically reconciled. 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 to what extent and under what circumstances this proposition is likely to be approximately valid or can be considered as a policy reference point.

76. The supply-side approach to the costing of environmental damage is based on looking at actual or prospective expenditures incurred in environmental protection or in abating or repairing damage, or for access to comparable amenities. We should, however, distinguish two sorts of reasons for such expenditures.

77. First, there is an imposed obligation to pay, in relation to damages for which the party is in some way held responsible. In this case the paying party is not motivated by consideration of the environmental benefits to be obtained. Examples in this category are: compensation payments by firms in cases of industrial accidents causing health problems to workers and inhabitants of surrounding districts; expenditures for environmental maintenance or restoration by firms related specifically to the sites and ecologically disruptive effects of the industrial activity; and taxes or fees paid for pollution. These are expenditures that are not in the direct economic/welfare interests of those making the payments. Rather they are imposed by an external authority, for example an eco-tax or pollution emissions charge. If their imposition reflects a notion of direct responsibility for the damage, we may speak of application of the "Polluter Pays Principle". (However, this principle may be implemented in a variety of ways and more or less rigorously.)

78. Second, there is a benefit obtained directly by the person or agency taking the protection, abatement or repair action. In this case the paying party is directly motivated by consideration of the environmental benefits to be obtained. Examples in this category of "voluntary" payments are commercial investments in purification of polluted water to be used for irrigation or as a manufacturing process input; or expenditures on medical treatment of respiratory complaints aggravated by city atmospheric pollution. The latter is a good example of environmental ‘defensive’ expenditures; another case would be costs of double-glazing of home windows to reduce traffic or aircraft noise.

79. We can also note that in the latter sort of situation, while benefits obtained and payment (of supply costs) are linked, there still may be no link being made between causation of the damage and payment; indeed, in the examples given, the original damage was presumably caused by others. The presumption is that a benefit is obtained by the person or agency making the expenditure, yet it is clear that (other things equal) the affected parties would be better off if the water and air were non-polluted and there was no need to make such expenditures. Thus, these are de facto situations of "Victim pays."

2.1.7 The problems of non-capture

80. In summary, 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) people's own "defensive" expenditures;

(c) people's "revealed" preferences for obtaining specified environmental services or amenities;

(d) people's "envisaged" or hypothetical preferences as elicited through contingent valuation, viz., willingness to pay or willingness to accept enquiries.

81. The above arguments and various examples show that monetary estimates of environmental benefits and damages suffered can have a clear policy-relevance in one way or another. But the "pricings" are not necessarily complete or "correct" in the sense of taking into account all environmental benefits and harms.

82. (a) On the supply side (I): Costs imposed. The levels of investments and expenditures by firms, individuals, and public authorities or of compensation for damage is not specifically linked to any estimate of the environmental values involved. The absence of a clear link can be due to (a) estimation difficulties or indeterminacies and (b) the necessarily political and administrative character of such impositions. Legally binding provisions for compensation payments do not necessarily cover the "full costs" of the damage as judged by the victims. There may, moreover, be long-term environmental damages for which no compensation is paid or payable, for example at Chernobyl or unnoticed toxic wastes.

83. (b) On the supply side (II): Costs actually incurred by choice. As already mentioned, actual expenditures made "voluntarily" and aimed to "supply" environmental goods and services — that is, investments and expenditures aimed to avoid environmental damage or to restore an environment that has been damaged — do not necessarily correspond closely to all the benefits that might be gained. This may come about either because the persons or society concerned do not perceive the benefits, or because they cannot "capture" the benefits and, as such, obtain a pay-back for their expenditures (In the example already given, the restoration benefits of forest replanting might be much greater than costs to a landowner, but captured by other persons over a long period of time.)

84. (c) On the demand side (I, II): Travel Cost and Hedonic Pricing. These methods capture preferences only insofar as they are "revealed" in or inferred 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.

85. (d) On the demand side (III): Contingent Valuations. The same remarks apply, generally, to the stated willingness to pay (or the demand for compensation) on the part of individuals for an environmental amenity or, for example, on the part of a commercial firm for access to (or the extra costs incurred in finding a suitable substitute supply of) a needed input or environmental service — such as timber, or volumes of water of a particular quality, or use of a river or sea as a receptacle for waste. Further, the absence of any real market for the goods or damages in question makes it is impossible to demonstrate that contingent valuation establishes "correct" prices, which leaves the figures obtained inevitably open to controversies.

2.2 Valuation of natural assets

86. It is clear from section 1.1 and 1.2 that valuation of the interactions between the economy and the environment is crucial to informed decision making. Unfortunately, it is also clear that valuing these interactions will be vastly more complicated than valuing purely market transactions, for two reasons. First, in many cases, market prices will not be observable for natural resources or environmental assets. Second, the extent of data that is available for the derivation of values may change drastically depending on the resource in question.

87. As discussed in Chapter 2, the SNA includes in its asset boundary natural assets over which ownership may be enforced and transferred; including both cultivated assets such as livestock that are under the direct control, responsibility, and management of institutional units and non-produced assets such as subsoil assets that may be owned but not under direct control, responsibility and management. Not included in the SNA are non-produced assets over which ownership cannot be enforced, such as open seas or air; the SEEA expands the asset boundary of the SNA to include these assets.

Economic and environmental assets

88. Economic assets are those recorded in the balance sheets of conventional national accounts, defined 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 or using them over a period of time. *Economic natural assets* can be produced assets such as agricultural or forestry products or non-produced assets such as land, mineral deposits or forests in the wilderness.

89. In the SEEA, economic, non-produced, natural assets are defined more broadly, including also those natural resources which are currently exploitable, or likely to be so, for economic purposes, even if no explicit ownership or control is currently exerted over these resources (e.g. fish in the oceans, or commercially exploitable timber in tropical forests). Thus, the SEEA knows two types of economic natural assets: economic natural assets as defined in SNA and 'sub-economic' assets, that have the same physical characteristics but for which ownership or control is missing. This second category is for the moment termed 'non-SNA economic assets' to separate it clearly from both SNA assets and from environmental assets. For example, uncultivated biological resources, such as tuna harvested from the ocean, are non-SNA economic assets, while fish raised in fish farms are economic (SNA) assets.

90. Environmental assets are defined as all *natural assets* that are not *economic assets.* Environmental assets are non-produced natural assets that do not function as providers of natural resource inputs into production but as providers of environmental services of waste absorption, ecological functions such as habitat or flood and climate control, and other non-economic amenities such as health and aesthetical values.

Depletion and degradation

91. Depletion of natural resources is defined separately for renewable and for non-renewable resources. For renewable resources, depletion is that quantity of the harvest, logging, catch or extraction that exceeds the sustainable level of resource use. Thus, for renewable resources, depletion is a net measure in the sense that, for the sustainable stock, depletion equals offtake less natural growth or replenishment. However, the actual stock of biological and other natural resources (e.g. aquifers) may differ from the sustainable stock so that temporarily a higher or lower offtake may be 'sustainable'. It should be noted that several levels of sustainable

use exist (one of which is normally termed the ‘maximum sustainable yield’). For non-renewable resources (e.g. mineral deposits), depletion is the quantity of the resource extracted. For the valuation of depletion see below and also chapter 2.

92. Degradation of environmental assets is defined as the reduction in the quantity and quality of the environmental assets. The deterioration in environmental quality may result from ambient concentrations of pollutants or from other activities and processes such as improper land use and natural disasters. A reduction in the quality only occurs when an environmental asset is polluted beyond safe absorption, i.e. beyond the sustainable level of absorption or regeneration of quantity or quality.

93. Adverse management practices, overexploitation of natural resources or residual flows above the level of safe absorption, while impairing the environmental asset, do not necessarily lead to an immediate deterioration of the flows of goods and services from that stock. By extension, the same applies to measures to improve environmental asset quality. For example depletion and deterioration of agricultural land (soil erosion, rising salinity, pollutant accumulation in soil) may not affect the current output, but could lead to a qualitative or quantitative loss of future agricultural output.

2.2.1 Valuation of stocks of natural resources

94. A detailed description of different valuation methods for stocks of non-financial assets is given in the SNA. Three main approaches can be distinguished for the market valuation of stocks of natural assets.

(a) Actual market prices of natural assets. This type of market valuation can be applied if market transactions involving the type of assets concerned are representative enough for their prices to be used for valuing the whole stock of assets. The use of actual market prices applies especially to land transactions and cultivated assets such as livestock. In other cases, natural assets are traded very infrequently, or not at all.

(b) Present discounted value of expected net proceeds. Net proceeds are defined as the net operating surplus that could be associated with the use of natural assets, diminished by a normal operating profit that could have been earned if the funds invested in the use of the assets concerned had been used for alternative activities carrying a similar degree of risk (OECD, 1986, p.6). This concept is very similar to that of economic rent of natural assets. In the case of depletable natural resources, net proceeds have also been referred to as net prices. The present value of expected net proceeds can be calculated by estimating the future net proceeds and discounting these income flows by a discount rate that reflects the risk of future earnings and the preferences for present versus future income flows.

(c) Net prices multiplied by the relevant quantity of the stock of natural assets. This valuation method has often been applied in the case of depletable natural assets; the net price (net proceeds) of the asset is the actual market price of the depleted raw material minus actual exploitation costs including a normal rate of return of the invested produced capital. The net price is then multiplied by the total quantity of depletable stock of the corresponding natural asset. The stock that may be valued using this technique comprises proved reserves that are exploitable under present economic conditions.

95. There are other valuation approaches not discussed in the SNA that may be useful for the valuation of non-SNA economic asset stocks. One approach is the use of option values, which reflect the prices paid for the option of exploiting resources once they are proved. These values are applicable to subsoil resources that have not yet been proved and exploited, but are probable and for which the option of exploitation may bring a

price. Another approach is to apply prices of similar assets or activities, adjusted to reflect the differences between the observable asset prices and those appropriate for the asset in question. For example, the prices of marketed, priced timber may serve as a starting point for the valuation of non-SNA economic timber, which is not currently marketable; in this case, however, the price applied must reflect the fact that the non-SNA economic timber is not currently marketed for whatever reason. Estimates of value for non-SNA economic assets can be based on mining lease options, the value of equivalent goods in the market economy, etc. Another alternative is the use of hedonic pricing which can be used to value both economic and environmental assets.

2.2.2 Valuation of changes in stocks of natural resources

96. The approach to valuing changes in stocks - depletion, degradation, additions, or improvements - depends on the approach used to value the level of the stocks. While different accounting treatments have been proposed for additions to stocks - either as investment in the asset accounts or as other volume changes - either treatment requires their valuation for monetary accounts. As in the valuation of stocks, the ideal and most direct valuation of changes in the stocks of natural resources is simply the use of their market price multiplied by the changes in the stocks. When market prices are not available, the methods above are applicable. Use of the present discounted value approach involves measuring the net present value of the asset before and after the change in the level of stocks; the difference between the two measures is the value of the depletion or addition to stock. Similarly, net prices, option values, or the prices revealed in hedonic or travel cost approaches to valuing stocks could be applied to changes in stocks.

2.2.3 Valuation of environmental assets

97. Environmental assets, as opposed to economic (including non-SNA economic) natural resources, are generally used as raw inputs into production in their natural state, and are not managed in any way. In many cases, it is the use of a service provided by an environmental asset that is involved in economic activity; an example is the ”disposal services” provided by clean air or water or the provision of stable water cycles or climate. This distinction suggests that a natural resource may have several components of value. For example, a forest may provide timber, a natural resource, and also provide recreational services while at the same time contributing to stabilising water cycles and local and global climate. As a result, a given economic activity may impact the value of these assets in different ways, and different valuation techniques may be required. These ”components” or ‘functions’ may be considered different assets and valued and treated separately in economic-environmental accounts.

2.2.4 Valuation of services of environmental assets

98. For some environmental assets, the valuation of a stock is not appropriate. This is true in the case of clean air, where quantities are not measurable or even relevant. What is relevant about these types of assets is the services they provide. In these cases, only changes in the assets - their degradation and restoration - need valuation, suggesting possibly different valuation techniques.

2.2.5 Degradation of environmental assets

99. From a supply-side perspective the degradation of air and water may be valued at the (hypothetical) costs associated with restoring the assets to some (perhaps politically determined) standard of quality or in the costs associated with maintaining that level of quality. These types of costs are discussed in section 2.3 of this chapter. From a demand side perspective, other ways to value degradation would be used.

2.2.6 Improvements to environmental assets

100. The valuation of improvements to air and water are more complicated. They could be valued according to actual expenditures involved in restoring them. However, this would require identifying, among total expenditure, those that correspond to the improvements separately from those that correspond to degradation avoided. Thus, indirect techniques, such as hedonic pricing or travel costs methods may be applicable. In these approaches, as mentioned above, the value derived from improving the quality of the asset is reflected in the prices charged by areas which offer them, or by the costs involved in enjoying them, as mentioned above. Contingent valuation may also be used for assessing improvements (and degradation), either using results of one-step procedures for different points in time, or using two-step approaches to value the improvements indirectly by the values ascribed to damages avoided. There are however problems attached to these methods. First, results of – typically local - studies must be aggregated to national totals, or transferred to other regions. Second, changes in asset value over time cannot easily be ascribed to improvements (or degradation) alone. The issue of revaluation and price changes over time has yet to be analysed. Third, hedonic pricing and travel cost methods are very limited in the kinds of environmental assets they can cover.

A classification of environmental assets and functions

101. Environmental assets are those for which neither ownership rights are enforced nor direct economic benefits (income) are derived from their use. Since many natural assets may exhibit both, economic functions and benefits as well as non-economic "amenities" or environmental functions, they are quite similar in categorisation to economic assets. The extended Classification of Non-Financial Assets (CNFA) of the SEEA93 (to be annexed) does, therefore, not distinguish between economic and environmental assets.

102. Environmental assets are often not really assets in a narrow sense but rather what is meant are certain ‘environmental’ or ‘non-economic’ features or characteristics of non-produced non-financial assets. Often such environmental features correspond to the services provided by the environmental assets rather than to the assets themselves and it is difficult to imagine an asset behind the environmental feature (e.g. clean air, stability of water cycles or climate). The term ‘environmental functions’ is used to make this clear. Environmental services for the purposes of the SEEA are defined as environmental functions, including spatial functions, waste disposal and life support. For example, a forest may, in addition to its economic functions such as supply of timber, mushrooms, berries and hunting products, have a function as a habitat for species, as a stabilising component of water cycles and of local and global climate, may exhibit protective functions against soil erosion, flooding, avalanches or landslides, may serve as a filter for air and water pollution and may also provide recreational functions.

103. Many environmental functions (or services) have no price but some of these environmental characteristics are actually captured in market values and can be revealed by e.g. the hedonic price method (for example private values of recreation or private values attached to houses situated in clear air or low noise

areas) and both an asset value (of the economic and the ‘environmental’ asset) and a value for the annual service can be derived.

104. Hence, in many cases, environmental and economic functions are actually features or components of natural assets rather than constituting separate assets. It is thus important to keep the values of assets and the values of the flows of environmental services conceptually separate. Furthermore, values that can actually be found do often refer to changes in quality of environmental services (rather than changes in assets or the values of the assets themselves).

105. De Groot's The Functions of Nature may be a useful reference framework as a list of things that can be valued. For the purpose of Chapter 5 a preliminary draft classification of the environmental functions is drawn up, as these are important for valuation (to be revised and completed):

1. climate protection (e.g. carbon sequestration in forests or oceans)
2. biodiversity protection and eco-system stability (e.g. of wetlands or rain forests)
3. recreation and amenity (e.g. of particular types of landscapes such as coastlines)
4. protective functions (e.g. against soil erosion, avalanches or floods)

106. Three purely environmental ‘assets’ are added to the SNA asset classification: air (quality), ozone layer stability and climate stability. (any more?)

2.3 Benefits-based estimates (demand side)

2.3.1 Damage valuation with the dose-response approach

107. Estimation of damages and of production losses with the dose-response approach refer to valuation of damages that can be quantified as losses of goods or services, be it goods and services sold on the market or environmental goods and services that can be compared with market equivalents of substitutes. As results are not actual but hypothetical transactions, care must be taken to avoid, in accounting, any overlap in values with the <u>actual</u> damage costs. The latter belong to the supply side and measure the part of the damages that resulted in actual transactions (see also the table in paragraph 112 below).

Method description

108. Estimation of the damage incurred by human activities (e.g. land use, pollutant emissions) is first done in physical terms, and then the resulting loss of goods and services that are used by society is assessed. The loss is then valued with

(i) Market prices
(ii) Derived prices (using prices for similar goods and services that are sold on the market)
(iii) Cost of maintenance or substitution (?)
(iv) Prices from preference estimations, e.g. willingness-to-pay estimations (see section 2.2.3)

109. Examples are damage to agricultural crops, reduced forest growth, soil erosion, corrosion of capital goods, health effects or reductions - in quantity or quality - of flora and fauna that are directly used by

households. The optimal method is to use dose-response functions, where the effects of e.g. a certain amount of pollution is described as a mathematical relationship to the impact on ecosystems, health, real capital etc.

Characteristics

110. This method is best used for well-defined goods and services that are provided both by the environment and by the economy. The method focuses on the economic effects of environmental deterioration (or, implicitly, improvements) and does not encompass broader welfare issues (e.g. existence values). The starting point are physical data on resource use and residuals (see also chapter 3, Physical accounts).

111. The part of damage estimates that relates to production losses is already captured by the conventional national accounts in a rather complex way, e.g. through (potentially) lower growth rates and higher prices. For this part, no 'environmental adjustment' should therefore be made. For example, losses of agricultural crops in the current accounting period can be estimated but should be separately shown. The following table helps to conceptualise this issue.

Effects on	market production	non-market production
This period	-	X
In later periods	X	X

112. The approach follows the theoretical definition of EDP/ENP in that it attempts to value the damage incurred by today's activities, now and in the future (although there are substantial problems to obtain dose-response functions for long-term effects, e.g. climate change). It refers to damages incurred by this year's economic activities, regardless of when the damage occurs. It focuses on flows of goods and services and estimates the impact on stocks by changes in the service flows (see also section 2.2.1 and chapter 2, Asset accounts).

113. The results refer to damage on the geographical territory. In elaborated versions of the approach it is possible, via linked physical accounts, to allocate the damages to domestic and foreign economic activities and sources that cause the damage. It is feasible to use this method to obtain results on a national scale.

114. The method is suitable to use when clear relations can be found between cause and effect but demands co-operation with natural scientists for determining physical connections and possible dose-response functions. Data must to be collected from various sources, e.g. environmental authorities, scientists, statistical offices.

Examples of two-step valuations with market and derived prices

115. Effects of acidification on fish stocks can be assessed as follows.

1. Required data are a map of acidification levels and fish stocks in the included lakes, emission data, model (or assumption) on deposition of emissions
2. Function: Deposition of X kg SO2, NOx and NH3 per area unit results in X units lower pH value
3. Assessment of the resulting pH value in lakes
4. Effects on different fish species at different pH values => loss of fish
5. The fish loss can be valued with market prices of the fish species or similar fishes. Extra losses due to reduction in the value of recreational fishing can be added.

116. Health effects of air pollution can be assessed as follows:

1. Required data: concentrations of pollutants in air (e.g. NOx, O3) in high-population areas. Relevant emission sources (mainly traffic)

2. Functions/relations: a) effects of different concentration levels of the studied pollutants on e.g. respiratory diseases (e.g. percentage extra sick leaves due to pollution) and b) amount of production loss, i.e. sick leaves, earlier retirement and untimely death due to the diseases
3. Percentage of sick leaves, earlier retirements and untimely death due to ambient concentration levels
4. The loss of production can then be valued with average wages, shortened life e.g. with the value of a statistical life or the value of life years lost.

Practical aspects/limitations

117. Limitation of knowledge about effects on the environment due to long-term or diffuse impacts from e.g. the deposition of pollutants. The effects often occur in the future, which means that assumptions on future emissions, use of resources etc. has to be made, with resulting uncertainty in results. Sensitivity analysis should be undertaken. Data difficulties: much of the data has to be gathered ad hoc. Time series on data other than those provided by statistical offices are usually not available. Narrow measure of the effects from environmental damage, since it does not include wellbeing from a healthy environment in a wider sense. Usually only a few goods or services that are affected can be included, and mostly only economic losses are estimated. Annualisation of the damage costs calls for supplementary information on the magnitude of the total effect. Limited in scope since only a few effects are quantifiable in the way requested. Only a partial adjustment of NDP would be possible.

Role in decision processes

118. In cases where the linking of cause and effect is possible, and the effects quantifiable, damage estimation can be done in the way described here. If monetary values are explicitly involved (e.g. natural resources that have economic value as a production input or as a source of tourist income), the process of elucidating conflicting interests might benefit from this kind of valuation. If, however, only a small part of the important effects can be captured by the valuation, it has to be supplemented with other assessments.

2.3.2 Direct and indirect demand-side valuation methods

119. It has often been suggested to use welfare economics based valuation methods like contingent valuation in relation with the compilation of environmentally adjusted national income figures. In SEEA (1993) the possibility to measure “imputed repercussion costs of households” with contingent valuation methods was mentioned, but considered a topic that needed far more investigation. In recent literature it has been suggested to measure the marginal social costs of pollution by these methods (Hamilton, 1994) or to measure the value of environmental services (Atkinson et al, 1997).

120. Environmental services can be conceived as the flow of services provided by non-market environmental resources. It has been suggested that they could be fit into the goods and service flow described in the national accounts framework. These services can be used as input to production (e.g. waste disposal service) or as a direct input in the utility functions of consumers (e.g. clean air). The value of these services is reduced by pollution emissions and can be increased by the regenerative capacity in nature itself and man-made improvements.

121. The prices on environmental services or in a broader term; environmental quality, should as far as possible reflect the consumers marginal willingness to pay consistent with the interpretation of the market

price of other goods already in the national accounts. There are mainly two groups of methods that have been used to estimate such values namely revealed preferences and contingent valuation.

2.3.2.1 Indirect methods (Revealed preference)

Travel cost method

122. The travel cost method can only be used to value natural or cultural sites that can only be visited after spending some money on getting to the site. The method is founded on the assumption of complementarity between the environmental good and a marketed good (e.g. transport costs). The better the environmental quality the more will be spent on transport for getting to this site. The method is quite limited and has lots of problems in the process of estimation. Moreover it is based on a number of very strict assumptions. They are: no utility derived from the travel itself, the value of time is equal to wages, no alternative sites available, only one site visited on every trip, the time spent on the site is the same for all visitors and so on.

123. There are typically three components to the "travel costs" that can be directly observed — the direct travel costs such as petrol 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 how near and accessible the site is by road, the income of the respondents, the alternative sites available. The costs and relevant information are usually obtained from a questionnaire at the site. Statistical methods are used to plot the relationship between travel costs and the number of visits made to the site, from which it is possible to calculate an average value per visit. This is then employed to calculate a monetary value for the recreational value of the site.

Travel cost method for estimating benefits: Example of forest recreation

124. Forestry management and policy making provides a good example of the problem of competing objectives: Forests are, at the same time, a source of timber, a habitat that sustains a variety of flora and fauna, an embodiment of cultural identity, an aesthetically significant landscape and a place of recreation. Several sorts of pollution can affect forest livelihood. In addition, the most cost-effective methods of timber extraction from forests often have an adverse effect on their landscape and recreational value; and conversely, management programmes to improve the mix and variety of timber may have costs in timber extraction.

Hedonic pricing

125. The hedonic pricing method is based on the idea that marketed goods can be described by a number of characteristics of which environmental quality is one. The relationship between price and the characteristics can be described by a so-called hedonic price function. If the particular contribution to the price from the environmental quality can be revealed we directly have an estimate of the willingness to pay for changes in the quality. In effect, Hedonic Pricing Methods employ a proxy good in the market to estimate individuals' willingness to pay for environmental goods and to avoid environmental damage. The most widely used proxy good is property (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. The differences in house prices where other factors are held constant give a revealed willingness-to-pay for the environmental benefits. This method only reveals the use-value of a specific environmental characteristic.

Example: hedonic pricing for estimating attribute value: damage from open-cast coal mining

126. Open cast coal mining is generally more profitable than deep mining. At the same time it is widely seen as the most environmentally damaging component, in terms of the visual impact, increased noise and traffic, dust during the operation and irreversible changes in the rural landscape it leaves afterwards. Thus for example, the profit for British Coal from the projected open cast mines in the Trent Valley, calculated at a discount rate of 8%, is £7.8m over the expected seven years of its operation. This represents an estimated £5.5 million greater profit than British Coal would receive from the production of coal in existing deep mined coal in the Trent Valley. However, these sums do not include external environmental costs of the operation.

127. Trigg and Duborg (1993) have reported an attempt to gauge the environmental costs by estimates of the fall in house prices in the local villages. Local estate agents were asked to consider the predicted changes in property prices. Trigg and Duborg concluded that 'once the environmental costs of opencasting are taken into account, the alternative deep-mined coal could be mined for roughly the same cost as opencast coal from the Trent Valley site. The result shows clearly that opencast coal mining in the Trent Valley is no more economic than existing deep-mined capacity.' This example actually uses a hybrid version of the hedonic pricing approach: it relies not on the actual behaviour of individuals in the housing market in response to environmental damage caused by open cast mining, but rather expert estimates of what the likely response will be.

128. The travel cost and hedonic price methods are quite limited in terms of the environmental services and assets they can cover and in terms of providing national aggregates for the issues they can cover.

2.3.2.2 Direct methods: contingent valuation

129. This method can be applied for a broad range of environmental questions. Only the contingent valuation method has the capability of measuring both the use and non-use values. The method has a number of variants with which to reveal the willingness to pay directly through interviews. The idea is to present a sufficiently large number of people with a hypothetical choice.

130. In general the questions can be posed in two different ways. The willingness to pay (WTP) question is "How much would you be willing to pay for some environmental quality" and the willingness to accept (WTA) is "How large a compensation would you accept to give up some environmental quality". In principle there should be no difference between the outcomes of these two different questions. However, numerous articles have pointed out that WTA answers are normally higher.

Some ambiguities associated with contingent valuation

131. Practitioners of contingent valuation, have, over the years, refined the approach and adapted it to a wide variety of situations. In doing so, they have themselves constructed a long catalogue of difficulties of implementation and obstacles in the way of effective use of the results in decision-making. Some of these difficulties relate to defining the "object" or service to be valued, others to the plausibility of respondent's value statements and the adequacy of the sample used.

132. 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 impossible to demonstrate that contingent valuation establishes "correct" prices, e.g., consistent with allocative efficiency and/or sustainability norms.

- One validation test is, when possible, to compare results from different elicitation procedures, to see if they converge on the same results. However, results from comparisons of CV, 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 is to concentrate on the internal consistency of the method. In part this involves trying to eliminate sources of ambiguity or "bias" that distort the discovery of the "correct” value for the good or amenity in question, and in part it involves trying to infer through statistical or sociological analyses the underlying meanings and determinants of people's responses.

133. The questions of "bias" or "illegitimate" responses are not simple to resolve. There are several sources of possible divergence inherent within the CVM itself. In particular, it seems likely a priori that there will often be discrepancies between expressed willingness to pay (WTP) for an environmental good and willingness to accept (WTA, the minimum acceptable compensation for loss of the good or of access). There are well-documented cases of individuals in real market situations with property rights who refuse to part with a good whatever the price offered, or would refuse compensation to accept some damage to their health or well-being. Similarly, figures obtained in environmental CV studies for compensation that would be demanded are often several times higher than for willingness to pay. Several plausible explanations can be offered. These include:

- the lack of budgetary constraints on the willingness to accept estimates,
- the fact that individuals are often loss-averse,
- the possibility that they are responding in some way on the basis of ethical convictions or "on behalf of" a larger community (so-called option, heritage, and existence values).

134. Academic debates continue about theoretical foundations for different CV questionnaire designs and interpretations. Equally significant have been efforts with the more pragmatic intention of arriving at values that are acceptable for policy makers. Particularly influential have been the recommendations of the NOAA panel of economists in the USA (NOAA 1993), where the question arose (among others) of the role of CV estimations for defining compensation for damages such as the 1989 Exxon-Valdez oil tanker wreck in Alaska. The approach adopted by NOAA was generally conservative, advocating those procedures that tend to produce modest environmental damage valuations. This included recommendations to eliminate "extreme" responses, and to prefer WTP formats over WTA formats since the latter generally resulted in higher values, sometimes much higher. Other recommendations included attention to the importance of accurate description of policies or programmes and information about alternative undamaged "substitute" sites available and the opportunity costs involved, follow-up questions to discover reasons for apparently discrepant replies to WTP questions, procedures for the elimination of "illegitimate" bids, and so on.

135. Sources of bias often cited in CV studies are:

1. Strategic and protest bids: Individuals can understate (free riders); overstate (strategic bidding); or might give a zero or very large bid because they do not accept the contingent valuation method itself (protest bidding).

2. Design effects: The way a bid is elicited can affect the outcome and different elicitation formats will produce different results.
3. Presentation and information effects: Generally the better the information and its presentation the higher the bid.
4. Payment vehicle biases: The popularity or unpopularity of taxes has a strong influence on WTP bids, while WTP into a private trust fund can be affected by the perceived trustworthiness of the fund.
5. Embedding and part/whole effects: Respondents to WTP surveys are apt to bid almost the same for the preservation of watering sites for 2000 migratory birds as they would for 200,000, (Desvouges et. al. 1993) or to clean lakes in one part of a region as they would for the whole region (Kahneman and Knetsch, 1992). Similar embedding effects can be arrived at by altering the payment periods for the goods in question.
6. Ordering effects: The order in which options are presented to the individual can affect the payments.
7. Framing effects: The way options are framed can change the response.
8. Compliance bias: Individuals may respond in order to try to please the interviewer.

136. Such divergences show that the distribution of property rights and also people's own views about the "rights and wrongs" of proposed policies or resource uses can affect the estimation of values. Interpretation of responses is further complicated by the diversity of respondents' views on rights and legitimate interests. Individuals are often reluctant to pay if they believe that they have, or should have, rights to the goods. In particular, where environmental damage is being done to a good that a person feels they have a right to, then moral appeal is often made to the "polluter pays" principle.

137. In the U.K. Pevensey Levels study, many members of the public expressed strong views about their "rights" to enjoy the countryside. Contrasting views were expressed by farmers, for example one comment on townspeople visiting the countryside to the effect that "they don't realise that we own the land. They think its national heritage and they can go where they like" (Burgess et. al. p.15).

138. The issue of willingness to pay is caught up in a much larger social issue of competing views of rights to the countryside and who has rights to expect compensation for producing an environmental good and who has the duty to pay. These sorts of issues become particularly important when addressing longer-term problems linked to economic and environmental sustainability — in this context the scientific and economic uncertainties, the conflicts of principle in society, and the conflicts of interest across different sectors and socio-economic groups can all become very large.

139. A common feature of these ‘benefit side’ valuation techniques is that they are concerned with limited, local and relatively small environmental questions. For the construction of environmentally adjusted national income figures or welfare indices we need to aggregate these estimates to a national level, and to aggregate the estimates of the values of all the various environmental services. That “is a formidable problem” (Atkinson et al., 1997).

Benefit transfers

140. Even though a large amount of WTP / WTA studies have been carried out, they only cover a small fraction of the environmental assets and services, i.e. not all environmental problems in all areas are covered. The literature using marginal damage costs in their calculations therefore relies heavily on benefit transfers.

This means that WTP / WTA results obtained in one study are transferred to a new environmental problem and also to other locations.

141. The method of benefit transfer is often used, but can be quite problematic. The main reason is that WTP / WTA studies are often specific to the site or the problem they relate to and hence difficult to transfer. In a more systematic way, Environment Canada, together with the US EPA, have set up a network and database of valuation studies, categorised by various characteristics. Similar activities are under way in Europe. However, it appears that so far little systematic knowledge on the exact methods to transfer results of existing studies to other locations etc. is available. Main issues are the corrections and weightings that have to be applied to the values when transferring them (e.g. income levels, distance of sites to population centres, etc.).

2.4 Cost-based estimates (supply side)

142. Costs in this section are defined in the same way as the costs of production are defined in national accounts. In cost-benefit analyses these costs are sometimes termed ‘resource costs’ as they represent the employment of (scarce) resources in the form of production factors and of goods and services (CBA also knows other cost categories such as direct and indirect costs, or private and social costs, not all of which are consistent with the SEEA). Theoretically marginal costs (and benefits) should be used for valuation. However, in practice such marginal costs are often very difficult to determine. National accounts use average costs and prices in numerous applications, and for environmental costs the same applies. Average environmental costs do approximate marginal costs and benefits under certain conditions (see Bartelmus 1998a, pp. 290/291).

2.4.1 Maintenance costs

143. According to the 1993 SEEA (para. 265/266) imputed environmental costs caused are valued at maintenance costs including imputed (hypothetical) depletion, degradation and restoration costs. The 1993 SEEA states that “maintenance costs are those required to prevent or mitigate deterioration of the natural environment.” For measuring degradation of natural assets the 1993 SEEA suggests to calculate imputed prevention costs or, in other words, imputed abatement (also called avoidance) costs. For example, in the case of actually occurring air pollution due to economic activities of the current accounting period, an estimate is made of the amount of money that would be required to prevent the occurrence of this pollution.

144. To rephrase the above, an estimate is made of the cost of hypothetical measures that would have prevented the additional environmental deterioration from occurring during the current accounting period (only the flow side is considered). It is important to note that this estimate does not represent the value of the damage caused by the additional environmental deterioration. That is to say, the size of the value obtained by this estimation method does not represent the severity of environmental problems; rather, it represents the ease, in terms of costs, of taking measures to rectify the environmental problems.

145. To the extent that imputed maintenance costs consist of consumption of fixed capital, intermediate consumption, compensation of employees, etc. they take on the same structure as the output of actual environmental protection activities (i.e. consumption of fixed capital plus intermediate consumption plus net value added). Accordingly, if the imputed maintenance costs and the actual output of environmental protection activities are estimated in the same structure and for the same environmental items, then both values can be regarded as complementary, with maintenance costs being the direct (though hypothetical) continuation of environmental protection activities already implemented (see chapter 4).

Procedure of Estimating Maintenance Costs

146. Sustainable use of natural and environmental assets refers to three functions of the natural environment:

- quantitative use of natural assets,
- spatial and qualitative use of land, and
- disposal function.

For the moment this section focuses on the disposal function (i.e. pollution).

147. Measures of five types for preventing or restoring environmental deterioration by economic activities can be distinguished:

(a) Reduction in economic activities or complete abstention from specific activities;
(b) Substitutions among the outcomes of economic activities, that is, production of other products or modification of household consumption patterns;
(c) Substitutions among the inputs of economic activities, without modifying their outcomes (output), inter alia, by applying new technologies;
(d) Activities to prevent environmental deterioration, without modifying the activities themselves (for example, by end-of-pipe technologies);
(e) Restoration of the environment and measures diminishing the environmental impacts of economic activities.

148. Accordingly, depending on the type of prevention and restoration of environmental deterioration listed in (a) to (e), the following may be considered as maintenance costs:

(a) decreasing amount of NDP through reduction or abstention of economic activities;
(b) additional expenditure when substituting the outcome of economic activities;
(c) additional expenditure when substituting the input of economic activities;
(d) expenditure required for activities to prevent environmental deterioration;
(e) expenditure required for restoration of the environment or measures to diminish the environmental impacts of economic activities.

149. For calculating the costs for type (a) and (b) the application of macro-economic models is necessary, while for the other cost types statistical data from enterprises (reflecting micro- or meso level) can be used as the starting point and modelling must only be used at the final calculation stage.

150. Basically, the procedure for estimating maintenance costs can be described as follows:

1) establishment of an environmental quality level to be maintained (ideally, the sustainability standard, in practice defined by policy);
2) identification of measures that would have to be carried out to secure the environmental quality level, or of measures for restoring environmental deterioration which actually occurred – i.e. the establishment of the exact measures as listed in (a) to (e)
3) calculation of the cost necessary to implement the measures identified in 2) above.

This procedure poses several difficulties.

Establishment of an environmental quality level to be maintained

151. The level of maintenance costs depends on the degree of deterioration of the natural environment and on nature's carrying capacity and save absorption levels and on the level of prevention and abatement already in place. That is to say, the reference situation against which costs should be measured is important for the definition of sustainability standards. In principle, from the viewpoint of environmental science, environmental conditions that pose no threat to human health or to ecosystems are the quality levels that should be maintained. However, in reality it is extremely difficult to establish such levels in a definite manner so as to calculate its maintenance costs. The definition of sustainability standards is not a task of statistical institutions. Often, 'sustainability standards' will be the result of political negotiation processes, that are informed by inter alia scientific knowledge and that can be supported by statistical authorities offering physical accounts as well as data like maintenance

costs. In addition, for the calculation of e.g. avoidance costs, the quality levels (stock standards) must be converted into emission reductions (flow standards). This would require physical modelling (see below).

152. The SEEA is designed for the purpose of obtaining macro-economic numerical values, which refer to the nation as a whole. Consequently, the specific measures identified should be aggregated. However, measures for achieving an environmental quality standard may often refer to individual areas (e.g. specific urban agglomerations). Hence, a review according to the actual state of environmental pollution in the relevant area should be made. In practical business, it is almost impossible to carry out such operations as a duty in the preparation of statistics.

153. In the first place, from the viewpoint of environmental science it is difficult to establish environmental quality levels to be maintained. In addition, environmental quality levels can be difficult to establish on the (ecologically artificial) scale of a country because other scales (e.g. local, watersheds, global) are more appropriate. Therefore, when environmental quality levels to be maintained from the viewpoint of environmental science are applied to estimation of maintenance costs for an entire nation, a rather complex procedure is required.

154. If an environmental quality standard per individual area can be identified, the following method should be considered in the estimation of maintenance costs.

1) All areas in excess of the environmental quality standard are selected. The maintenance costs in areas where the environmental quality standards have been achieved is zero.
2) A combination of measures for achieving the environmental quality standard per individual area is decided. In order to decide on a combination of measures, through implementing environmental pollution simulation per individual area, we should confirm whether the environmental quality standard could be achieved by implementing the combination of measures. This selection involves several stages. First, possible measures or combinations of measures are identified. Second, as some categories of measures affect the levels of emissions rather than directly the quality levels, physical modelling is required to estimate the effects on the quality levels. Third, the least costly combination of measures must be selected.
3) The expenditures in one accounting period necessary for implementing the combination of measures selected are calculated. These are the maintenance costs of the relevant area. Aggregation of all areas results in the maintenance costs for the whole country.

155. As described in 2), environmental concentration of a pollutant depends not only on the volume of the pollutant but also on the environmental capacity per individual area (such as soil, land cover, relief or weather conditions) and actual pollution. Consequently, unless we consider such matters and implement pollution simulations, the links between environmental measures and environmental concentration cannot be established, and maintenance costs cannot be calculated. Such operations are simply the process of formulating environmental policies that have taken labour and time. We are thus compelled to say that such operations are beyond the boundaries of operations for the purpose of preparing statistics, such as the SEEA.

156. Furthermore, considering that it is impossible to achieve an environmental quality level to be maintained from the viewpoint of environmental science, as is the case with e.g. global warming, it would be feasible to estimate the maintenance costs based not on an environmental quality standard but on a target of environmental policy established in advance (for example, the target amount of reduction in CO2 emissions). 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'.

2.4.2 Calculation of Abatement/avoidance costs

157. Imputed abatement costs reflect the hypothetical additional costs for specific prevention measures that would have been incurred if the polluting economic activities had been modified or their impacts mitigated in such a way that the natural assets would have been less disturbed than in the actual situation without such additional measures. Imputed abatement costs as part of maintenance costs refer to direct pressures on the natural assets (e.g. air emissions, waste disposal), their calculation does not require the definition of environmental quality levels or standards but of residual flow standards. Ideally, imputed abatement costs should always be seen as the sum of direct and indirect cost effects of additional prevention measures.

158. This section concentrates on the conceptual and empirical steps necessary for the calculation of direct abatement costs. The envisaged data should fit to table 4.5 of SEEA (p. 110). The need for and ways how to use econometric models will be described later in section 3.2.

159. Different types of measures (see types a) - e) above) to reduce pressure on environmental assets exist. Direct abatement/avoidance cost calculations concentrate mainly on technical measures (end-of-pipe and integrated types, following c) and d) above). These ones are also called 'efficiency measures'. The types a) and b) can be defined as 'structural' or 'sufficiency' measures. Structural measures do require modelling to determine the hypothetical costs associated with these measures.

2.4.2.1 Key conceptual elements and restrictions of direct abatement cost calculations

160. Abatement cost calculations refer to pressures by economic activities on the environment of one country and in one year, e.g. CO_2 emissions in 1999 (flow side). Pressures comprise mostly discharges of different kinds of residuals but may include land use and quantitative use of natural assets as well. The economic structure and technological options prevailing in the current accounting year are valid.

161. Usually abatement cost data is collected on a micro-economic level, describing 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, per type of measure, the costs 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. However, there are complications. In studies of CO2 abatement costs it is often found that substantial initial reductions can be obtained at negative costs e.g. 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 the 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.

162. Total abatement cost can be derived from such cost functions by combining these with given environmental standards or targets, e.g. a certain reduction of annual CO_2-emissions. The availability of environmental standards or targets is not a precondition for the calculation of abatement cost curves. Rather, abatement cost curves are used to inform the target setting processes.

163. There are different levels of complexity for direct abatement cost calculations: calculations of abatement costs for one pollutant, abatement cost calculations for a set of pollutants contributing to a certain environmental problem or theme and on the highest level abatement cost calculations for all environmental problems at once caused by individual activities of the national economy. Consequently, single and compound cost curves exist.

164. The additional costs for technical measures for one statistical unit or economic actor are defined as direct costs. If the measures were applied (hypothetically) in a whole industry, this would in principle already affect the cost structure and the prices and level of output of this industry. In many cases a broader economy-wide application of such measures is necessary to achieve the given environmental targets (e.g. CO2 reduction, reduction of air pollution in general, reductions in the amounts of solid waste generated, changes in agricultural practices, etc.). This has an influence on the system of prices in the economy and on the structure of output and intermediate consumption of many industries, which leads to changes in the structure of the economy. Such an effect is called indirect effect. For the calculation of direct and indirect costs, i.e. in order to obtain the total costs of technical measures, modelling applications are necessary (preferably with an input-output core) and have to be closely linked with direct cost calculations. Thus, assuming simple additivity of direct avoidance costs originally obtained at a technical (hence, strictly speaking, at a sub-establishment) level can generate very misleading (or meaningless) results as these results may bear no relationship at all with the macro-economic effects that would actually occur if the hypothetical measures are being implemented.

165. Consequently, the accounting of abatement costs is different for the micro-economic (individual economic agents and establishments), the meso-economic (industries and homogeneous branches of production, and groupings thereof) and the macro-economic accounting levels. The second and third levels are outside the framework of direct avoidance cost calculations. Of course these levels are interlinked and avoidance costs for SEEA purposes have to be converted stepwise to the macro-economic accounting level.

2.4.2.2 Steps of empirical realisation

166. No generally accepted guideline or method for the construction of direct abatement costs conceptually consistent with the SEEA-framework is at hand. Based especially on the international climate change discussion certain research projects were conducted including calculation of abatement costs for technical reduction options and scenarios reflecting the micro-meso accounting level but not corresponding to national accounting rules. Usually, this kind of data does not take indirect cost effects into account. Therefore it has to be converted to be in line with SEEA purposes. Generally speaking, to calculate imputed abatement costs needs basic data from the technical sphere as well as the economic accounting sphere. Only the latter is the usual area of work of statistical institutions.

167. Three types of data are required. Technically disaggregated data on emissions by economic activities and underlying production processes, parameters of available abatement techniques/measures (e.g. reduction

potential, actual rate of application per production process/economic activity) and cost data for these measures.

168. The linkage of technical data/classifications and economic data/classifications is necessary in order to obtain all data for the required standard statistical economic units compatible with SEEA classification of industries. This necessitates bridging the technical sphere and the economic accounting/statistical sphere. Often the emission data and the technical abatement data originate from technology-oriented databases that use technical rather than economic statistical classifications and, therefore, need to be converted.

169. Cost data for abatement measures are available on a micro-economic level (technical/production process and sub-establishment level), aggregation up to meso- (industry/branch) and macro-economic level is required.

170. Detailed assessment of data for all three basic data-types is necessary, mainly in the light of availability, up-to-dateness, reliability, degree of detail and correspondence between theoretical and statistical terms and definitions.

Limits and problems of direct abatement cost calculations

171. Empirical experiences so far showed a lack of adequate, SEEA-compatible primary data. Comprehensive official databases integrating data of the three basic data types (current emissions and technologies used, technical options for reduction and their economic characteristics) are not yet available. Instead, a lot of different data sources, from official statistical authorities and from research institutions, have to be assessed and combined. The situation will get better in the future with the enforced activities of international organisations to build up homogeneous technical databases for the process of defining BAT-techniques in a broader context (BAT=Best Available Technology).

172. Direct abatement cost calculations should – as far as possible – take account of interactions between technical abatement measures, interactions between pollutants, incompatibility of abatement measures and the uncertainties of measurement of integrated techniques. Such kinds of problems are treated very rarely in primary data sources.

173. With respect to calculating the costs of measures, one should also mention that it is not always easy to distinguish between costs for environmental protection and other costs. If it is a cost for end-of-pipe technology, it is justifiable to deem it entirely as a cost for environmental protection. However, when the cost for energy-saving technology for reduction in CO2 emissions is deemed entirely to be a cost for environmental protection, questions still remain. Moreover, in the case of developing new vehicle engines that reduce NOx and CO2 emissions and also increase energy efficiency and generate more power, it is difficult to specify the portion of the greater engine cost due to environmental protection.

2.4.2.3Direct avoidance cost calculations and modelling

174. The results of direct avoidance cost calculations for the micro- and meso-economic accounting level – as described above - are only partly consistent with SEEA-maintenance cost at a macro-economic level. Therefore, and in order to convert these cost data into meaningful macro-economic aggregates, modelling must be used (see section 3.2 Accounting versus modelling).

175. On the other hand, in the estimation of e.g. the maintenance costs of global warming due to CO2, through using a model simulation, one may establish a combination of the most economic and rational efficiency and sufficiency measures and calculate these costs. Of course, the results in this method are determined by the accuracy of the simulation model and basic data.

176. As mentioned above, various issues must be kept in mind when estimating maintenance costs. If we try to calculate the “real maintenance costs,” extremely huge volumes of data are necessary. On the other hand, basic data for this is extremely scarce. In the SEEA, it is thus necessary to consider the degree of accuracy that should be achieved for “maintenance costs” and how the results should be interpreted or utilised when high accuracy levels cannot be achieved.

2.4.3 Restoration Costs

177. The term ‘restoration costs’ in this valuation chapter has two meanings. One is the ”actual costs” for restoration activities that were actually carried out, the other are ‘imputed’ restoration costs as part of the maintenance cost approach. The actual restoration costs could be interpreted as the (minimum) value of environmental deterioration that has already been restored by the restoration activities (see the SEEA 93 para.49). The hypothetical restoration costs could be interpreted as the value of present environmental deterioration that is not restored. In valuation, hypothetical restoration costs must be used alternatively to avoidance costs (and the least-cost option chosen).

178. The actual restoration costs are estimated on the basis of actual expenditure for restoration activities, and they reduce imputed avoidance costs which are normally estimated assuming the absence of any restoration (see the SEEA93 para.261. In the Japanese SEEA application this method was used).

179. The hypothetical restoration costs are one of the categories of the maintenance costs (imputed environmental costs) for present environmental deterioration. The hypothetical restoration costs would only be used as the maintenance costs if they are the ‘least-cost option’ The hypothetical costs of restoring the environment to defined sustainability standards are important outside the national accounting framework. The hypothetical costs include the mitigation/abatement of accumulated damage required to return to this standard. Therefore, they could become part of extended national accounts, if financial (portfolio) issues are addressed, notably in term of an ”environmental debt” concept.

2.4.4 Actual damage-related costs

180. Damage-related costs refer to the extra costs incurred on the economy by environmental pressure, e.g. additional costs for health care or damages to real capital. Whereas restoration costs (section 2.4.3) refer to restoration of the environment, the damage-related costs refer to treatment or restoration of human-made capital and human health, and costs incurred to replace lost environmental functions. These cost estimates are supplementary to data on environmental protection expenditure (chapter 4) and restoration costs.

Method description

181. Estimation of the part of costs for treatment and restoration of human-made capital or human health that can be ascribed to environmental deterioration requires linking causes and effects. For some damages, this connection is straightforward. For others, such as effects from air pollution, the link between cause and effect is ambiguous. In those cases strong assumptions have to be made to account for the alleged costs. Examples of costs: building renovation, medical treatment, and replacements due to additional corrosion. Costs incurred to replace lost environmental functions are included, e.g. building of dams to compensate for lost forests, or sewage treatment plants to compensate for drained wetlands.

Characteristics

182. This method focuses on effects on goods and services provided by the economy and on economic assets by means of disaggregation of the conventional accounts. The results refer to costs incurred during the accounting year by domestic economic actors, regardless of when or where the causing activity took place (e.g. when the pollutants were emitted).

183. Direct and indirect costs can be calculated. In the case of indirect cost calculations the estimations have to be based on physical data on resource use and residuals (cf. Ch.3, Physical accounts). The method demands co-operation with natural scientists for determining physical connections and possible dose-response functions. Data need to be collected from various sources, e.g. environmental authorities, scientists, statistical offices.

Practical aspects/limitations

184. The method faces data problems for important areas. It is for example hard to determine the part of actual damage-related expenditure (as well as imputed costs – see above) in the fields of health damage. The method cannot cover evasion expenditure very easily. It is hard to determine causes of the costs incurred (domestic or foreign economic activities, natural causes versus economic causes, etc.). In some cases strong assumptions have to be made.

2.5 Physical basis and evaluation

185. A function of valuation is the reduction of complexity. Physical aggregation methods can be used for reducing complexity. Examples are the theme-equivalents and other physical aggregation methods as outlined in Chapter 3. There are also more controversial methods to aggregate physical data, such as pressure indices (where expert assessment is used to determine the relative weight of single indicators beyond the theme equivalents approach), ecological footprint or TMR. The theme-equivalents clearly qualify for recurrent accounting due to their scientific base and due to their being part of international agreements and recommendations (e.g. IPCC for global warming potential, Nordic Council for acidification and eutrophication equivalents). For other methods, for which a broad consensus is only just developing, experimental accounts can be drawn up.

186. As the descriptions of the valuation methods (see sections above) show, physical datasets and accounts are a crucial precondition for valuation in various respects. First, the physical quantities (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. Second, for some methods detailed interlinked physical accounts are necessary to enable valuation and to support the analytical applications of the environmental accounts. Examples in point are the avoidance cost calculations (where detailed data on the technologies used by different industries and households, the residual flows generated by industries and households, etc. are necessary) and the damage valuation via dose-response functions.

187. For example, the ideal dataset for damage cost estimates includes emissions by industries in a (regionalised) NAMEA-type framework, linked to physical distribution models for the pollutants, which are in turn linked to ambient concentrations in a geographical breakdown and linked to population affected. This dataset allows calculating, with the help of dose-response functions, the physical impacts and damages (respiratory diseases, damages to buildings, etc.) which then in turn can be valued in money terms. In analytical applications, this linked dataset allows to establish a link between the monetary value estimates of damages to the initial causes (domestic and abroad) and to model the effects of alternative policy options, distributed geographically and by industry, on the damage estimates. The NAMEA-type framework allows to directly link the avoidance cost calculations to the damage cost estimates so that for each policy option a cost-benefit comparison can be performed.

2.6 Summary assessment

(To be added later – see also introduction)

3 Accounting and aggregation

3.1 Applications of environmental accounting

(section 3.1 text provided by Peter Bartelmus - slightly expanded thereafter)

3.1.1 Valuation and aggregation

188. As mentioned in section 1, the reasons for aggregation are:

- Scarcities in environmental source and sink functions due to overuse of environmental functions by economic (production/consumption) activities.
- At a micro-level costs of supplying/maintaining environmental functions need to be weighed against benefits (welfare effects). At the macro-level the interdependence of the environment and the economy calls for integrative policies for sustainable growth and development. Integrative policies need integrated databases.
- National accounts have been blamed for providing wrong signals by overlooking environmental costs and counting environmental protection expenditures as progress, which undermines the economy and leads to environmental destruction.
- On the other hand, national accounts have the greatest integrative power owing to their "ability to link numerous, very varied phenomena by expressing them in a single accounting unit" (SNA 1993, para. 3.70).
- Applying SNA's (price/cost) valuation to scarce environmental assets and changes therein permits comparison and aggregation of heterogeneous environmental and economic phenomena (see section 2) in consistent accounting terms. Information overload is reduced for decision-makers.
- As a result, environmentally adjusted aggregates/indicators can be obtained with which decision makers are familiar and which they can use directly in economic policy making and analysis (see section 3.13).
- Environmental costs of natural resource depletion and environmental degradation may already be accounted for in corporate accounts, notably when natural resources are exploited by owners. In this case environmental costing corrects inflated conventional values of production.

189. On the other hand, there are also good reasons against aggregation and the compilation of environmentally adjusted aggregates:

- Different priorities (with exceptions) of industrialised and developing countries: former focus on pollution, latter on natural resources. Result is rejection of more controversial valuation of externalities (e.g. NAMEA) by national accountants in European countries, while developing countries stress the need for natural resource valuation (see e.g. recent ECA seminar and SEEA case studies).
- Rejection of an EDP and, implicitly, valuation even at sectoral level (EVA) on theoretical and practical grounds.
- Monetary valuation is modelling whereas environmental accounting provides 'just' the basic data sets for analysis and modelling (Greenstamp). There is a need to distinguish between descriptive and behavioural modelling: the former is common practice in national accounts and also in environmental data estimation.

- When accepting some valuation/costing, it is enough to show (sectoral and total) cost without deduction. However, others may perform analyses, though (and possibly inconsistently with national accounts definitions as e.g. in welfare measures, see section 3.1.4).

190. Conclusion:

1. It is essential to distinguish between accounting for natural resource depletion (which yields EDP I, below) and additional accounting for environmental degradation (maintenance) costs (which yields EDP II, below).
2. The scope of environmental accounting and descriptive analysis should not be limited by shifting the valuation of environmental impacts entirely into the research and modelling field.
3. From growth to development: development goals of equity, health, freedom, political stability etc. cannot be quantified in monetary terms unless resorting to doubtful demand-side valuations. Need for physical indicators and related standard/goal/norm setting.

3.1.2 Environmentally adjusted indicators

191. Scope, coverage, limits

- Public goods are included in national accounts with the argument of market failure (SNA 1993, para. 9.84 and 9.92). This argument can be extended to the environment (government as caretaker of public good, see Bartelmus, 1998a, p. 290) which leads to extension of the asset boundary to include non-produced economic and environmental assets (see Table 1). Relevant accounting indicators are natural capital and changes therein.
- Different valuation techniques determine the coverage of environmental impacts and effects. Market valuation of natural resources obtains a value of non-produced economic (in SNA sense) assets and asset depletion. Maintenance costing extends the coverage to environmental asset/function losses (notably from pollution). Both valuations treat environmental impacts as capital consumption (assuming that the environment provides factor services for production), obtaining environmentally adjusted net value added. Damage (contingent etc.) valuations assess welfare losses (effects on health, recreation and ecosystems), obtaining net benefit values.
- SNA/SEEA do not aim at welfare measurement, but sustainability of economic performance (e.g. contingent valuation is inconsistent with market valuation: inclusion of consumer surplus). Welfare measurement should be left to cost-benefit analysis or to indices developed outside national accounting such as the Genuine Progress Indicator, the ISEW or the Human development Index.
- Question: should damage/benefit valuation be included in satellite accounts (e.g. through extension of the production boundary – nature production account a la Peskin) for calculation of national “net benefit”? Risk of valuation mix (e.g. cost caused and borne).

192. Concepts and definitions of green aggregates

- Table 1 facilitates definition of green accounting aggregates through expansion of asset boundary and introduction of environmental costs in accounting identities (details see Bartelmus 1998b).
- EDP I and II: deduction of environmental cost EC (natural resource depletion, depletion and degradation, respectively) from NDP obtains ‘net’ (duplication free) or ‘more sustainable’ NDP.
- EVA I and II: sectoral breakdown of EDP through cost allocation to causing sectors.

- CAP_n: stocks of natural resource capital obtained through valuation of economic assets (as contained in SNA asset accounts). Environmental assets are hardly possible to value (use of option/existence values) and should be presented in physical terms only.
- ECF I and II: deduction of natural capital consumption from net capital formation (note: natural capital consumption equals environmental cost in analogy to conventional capital consumption). ECF III: suggested inclusion of ‘discoveries’, notably of (non-produced) mineral deposits. Question of consistency with SNA production boundary – capital is produced by definition. Note: only exploration costs are accounted for as capital formation.
- Environmentally-adjusted National Income (ENI): used for incorporating cross-boundary environmental impacts (in addition to deducting environmental costs caused domestically) as transfers from/to the rest of the world. Also proposed for incorporating environmental damage costs borne for the measurement of economic welfare. Close, but not identical with, Hicksian income concept (difference in concepts of changes in net worth and saving).
- Genuine saving (S_g): similar to ECF. Contrary to capital formation, savings refers to disposable income (including income transfers from/to abroad) not used for consumption. S_g as defined by the World Bank (1997) deducts the cost of natural resource depletion and pollution damage (the latter at a “place holder” value of $ 20 per ton of carbon emitted) and adds a human capital formation component of educational expenditures. This addition changes the consumption concept of the national accounts.
- Environmental protection expenditures (EPE): already covered in the SNA. Segregation/classification problems. Deduction from GDP as “defensive expenditure” suggested to improve use of GDP as welfare indicator (inconsistent with SNA concept of measuring market transactions).
- Environmental debt (ED): accumulated environmental cost over more than one accounting period (restoration cost concept applied). Consistent with financial debt definition?

193. The proliferation of hardly comparable and inconsistent (with standard economic accounting procedures, definitions, indicators) indices of Genuine Progress (GPI), Sustainable Economic Welfare (ISEW), Human Development (HDI), Value of Nature Services, Natural Capital etc. calls for some harmonisation and standardisation within a common accounting framework. The SNA as a worldwide adopted framework should be used as starting point, making any necessary deviations in its satellite explicit.

3.1.3 Indicator use and analysis

194. What the environmental adjustments are trying to measure are present wealth, future costs, and sustainability. Data requirements are environmental expenditure, maintenance costs, etc. A key question is what data the environmental accounts can actually provide (and what is actually being measured if ideal data are not available).

195. Score keeping

- Assessment of sustainability of economic performance and growth. Sustainability defined operationally as produced and non-produced capital maintenance.
- EDP: measure of ‘more sustainable’ economic performance/growth (Bartelmus, 1998b, p. 5).
- ECF/S_g: when negative, measures non-sustainability; when positive, indicates weak sustainability (ignoring possible complementarities of factor inputs).

196. Policy formulation and analysis

Comprehensive assessment of a multi-purpose data system is difficult if not impossible. Table 2 lists therefore a number of possible managerial and policy uses of selected indicators, either directly or through the filter of modelling. Two major illustrative uses of indicators at macro- and meso-levels are:

(i) maintaining natural wealth/capital: see CAP_n, $\in CAP_n$ and $EDP/CAP+CAP_n$ (also ECF and S_g) and

(ii) Cost internalisation by households and enterprises: setting economic instruments at environmental cost (average EC) for sectors; additionally: modelling production and consumption patterns.

Table 2. Policy analysis of green accounting aggregates

Environmentally adjusted indicators		**Policy analysis**	
		Macro-analysis	**Micro/meso-analysis**
Stocks and change in stocks	CAPn = natural capital	Natural wealth categories; comparison with total economic capital and wealth; portfolio analysis of development finance; debt servicing capacities of natural resource dependent countries	Distribution of natural wealth among economic sectors (property rights, equity, distribution policy)
	∈CAPn = changes in natural capital stock	Causes of stock changes: exploitation, growth, land use, natural disasters etc.; environmental-economic policy trade-offs	Changes in capital stock by causing agents (industries and households)
	EDP/CAP+CAPn = environmentally adjusted capital productivity	Comparison with conventional measures of (capital) productivity	Comparison of conventional and environmentally adjusted capital productivity; sectoral investment policy
	ED = env. debt (accumulated env. cost)	Liability of past to future generations (enhancing inter-generational equity)	
Flows	EDP = environmentally adjusted net domestic product	"More" sustainable indicator of economic performance and growth (per capita, constant prices); score keeping of policy success/failure; comparison of growth rates; ranking of countries	Environmentally-adjusted value added: net (of environmental cost) indicator of economic performance and structure
	Ratios per EDP (budget deficit, trade balance, debt, consumption, env. protection expenditure etc.)	National and international comparative analysis and policy of trade, indebtedness, consumption, saving, investment etc.; modelling import and export of sustainability	
	EC = environmental depletion and degradation costs (total EC and as per cent of NDP)	Assessment of social cost that should be incurred to achieve sustainability in economic performance and growth; international comparison; rent capture for reinvestment; modelling 'optimal' EDP	Costs to be internalised into the budgets of households and industries; initial level of fiscal (dis)incentives for changing production and consumption patterns; scenario modelling
	ECF = environmentally adjusted capital formation	Sustainability of economic growth	Sectoral breakdown of net capital formation for reform of investment policy
	Sg = genuine saving	Domestic saving available for capital formation after environmental costing (growth/investment policy)	
	EPE = env. protection expenditure (current, capital expenditures, green taxes, etc.)	National environmental policy response (by environmental area); employment policy (generation of employment in protection industry	Environmental responses by economic sectors; green business opportunities; assessment of eco-efficiency of economic performance; competitiveness of industries

Source: Bartelmus (1998b).

Table 1. Environmentally adjusted accounting indicators

	DOMESTIC PRODUCTION	FINAL CONSUMPTION	CAPITAL FORMATION	CAPITAL	REST OF THE WORLD
OPENING STOCKS			Economic assets	Environmental assets	
			+		
SUPPLY OF PRODUCTS	Output (O_i)				Imports (M)
USE OF PRODUCTS	Intermediate consumption (IC_i)	Final consumption (C)	Gross capital formation (CF)		Exports (X)
USE OF FIXED CAPITAL	Fixed capital consumption (CC_i)		Fixed capital consumption (-CC)		
Value added (VA), NDP	$VA_i = O_i - IC_i - CC_i$ NDP = VA_i				
USE OF NATURAL ASSETS (depletion and degradation)	Environmental cost of industries (EC_i)	Environmental cost of households (EC_h)	Natural capital consumption (-EC)		
Environmentally-adjusted indicators	$EVA_i = VA_i - EC_i$ EDP = EVA_i - EC_h		ECF = CF - CC - EC		
			+		
			Other changes of economic assets	Other changes of environmental assets	
			=		
CLOSING STOCKS			Economic assets	Environmental assets	

Source: Bartelmus (1998b).

3.1.4 Description of welfare indicators

197. GDP is the key indicator of performance in terms of economic production, but it has also been used widely as an indicator of (economic) welfare. Especially in its property as welfare indicator it has been criticised a lot during the last 50-60 years. The accusations in this respect have been that some aspects included in GDP do not enhance welfare and some very important aspects that are not even included, but are measurable in economic units, actually do enhance welfare. Consequently GDP is regarded by many as giving misleading information about the true economic development.

198. The likely effect on human welfare from the extraction of natural resources and degradation of the environment is one of the aspects, which is not reflected properly in GDP. This lack of environmental considerations other than strictly commercial ones has been a motive behind the criticism of GDP in the last 30 years. The national accounts are set as a multipurpose system designed to meet various requirements. A change in the system to make it produce a better measure of welfare will reduce its value in other uses. This is maybe the main reason that it has not been changed.

199. Politicians and the public are used to react on only a few aggregates like the rate of unemployment, the rate of inflation and the growth of GDP when they are dealing with macro-economic policy. Therefore the presence of environmental problems and trade-offs between economic and environmental goals, generates a distinct need for aggregated indices weighing together these different aspects of economic performance and welfare.

200. Among the number of different ”green accounting” responses to this demand one category is concerned with the construction of welfare indices. Three of the most well-known are the Measure of Economic Welfare (MEW) by Nordhaus and Tobin (1972), the Net National Welfare of Japan by Economic Council of Japan (1974) followed up by Professor Uno and the Index of Sustainable Economic Welfare (ISEW) by Daly and Cobb (1989). Actually they are neither direct measures of welfare nor indicators of true welfare, but rather a measure of the value of most of the welfare generating goods and services. Thus what is measured is the value of some of the inputs in the welfare function and the idea is that there is a positive relationship between the value of input (in fixed prices) and output (welfare itself).

201. Although much of this work is driven by environmental aspects, the basic idea behind it is that if the intention is to create an index, which describes the development in economic welfare better than GDP does, environmental matters are not the only adjustment that should be considered. Other adjustments are e.g. the inclusion of the value of household work and leisure time.

202. One of the main proposals for correcting GDP is the idea of subtracting environmental defensive expenditures. These expenditures are described in chapter 4. Nordhaus and Tobin (1972) described them as ”regrettable necessities” meaning that they do not contribute directly to welfare themselves but are a necessary input to utility yielding activities. So they can be seen as cost to production rather than final consumption.

203. By definition environmental expenditures in production are not included in GDP, because here they are regarded as intermediate input. However, there may be some spillover to GDP through changes in prices. In nominal terms there may be forward incidence meaning that increasing costs of production are added to the prices of the final products. There may even be some effects on GDP in fixed prices if the process of deflation in national accounts is not able to identify all the causes of the price increases.

204. So the only defensive expenditures that should be deducted are those appearing in final consumption. This can be e.g. waste removal, treatment of household sewage, catalytic converters on cars and various environmental expenditures showing up in final government consumption.

205. The concept of defensive expenditures has been subject to long discussions in the literature. Are they welfare enhancing or not? It is quite clear that if we consider only one year we are better off **with** the expenditures than without. In a dynamic framework the situation is different.

206. Here the differences in the opinions seem to stem from different initial situations considered. Are the expenditures a **reaction** to increasing environmental degradation compared to the initial situation, then the welfare contribution from the environment is **maintained** by these expenditures and they should be deducted in order not to indicate an increase in welfare. If the degradation of the environment has not increased compared to the initial situation, then environmental expenditures will **improve** the environment compared to the initial situation and therefore they should not be deducted thereby indicating an improvement in welfare.

207. Another environmental correction needed in these measures is one that mirrors the changes in the environmental quality that has taken place **despite** the activities paid for by defensive expenditures. Daly and Cobb deduct damage costs related to, among other things, air, water and noise pollution. In addition they have deducted a ”rather speculative” estimate of long-term environmental damages primarily due to climate changes. These damages are assumed to be ”cumulative” and directly related to the consumption of energy.

208. Nordhaus and Tobin believed that the exhaustion of resources was no threat to sustainability because the price on resources had not increased more rapidly than other prices. The explanation was that substitution and technological changes had avoided scarcity. Daly and Cobb do not acknowledge this argument. Recourse prices are rising they say. So in contrast, they propose that any reduction in future welfare due the exhaustion of resources should be deducted from current welfare (cost caused principle). Thus, they estimate the amount of money that would need to be set aside to compensate future generations for the loss of services from non-renewable energy resources and other mineral resources. They do not discount future costs.

209. In Economic Council of Japan (1974) and in a Danish example (Jensen (1995)) the effect of environmental degradation on the indicator (i.e. the value of the economic inputs to the creation of welfare), was estimated as the costs (avoidance costs) that would have been necessary in each of the years in the accounting period to maintain the environmental quality on a certain level. In the Japanese

example this was the level of environmental quality in 1955, and in the Danish example it was more like some environmental standards and political goals.

210. One of the main conclusions drawn form the Danish project was that the relatively small environmental corrections drowned completely in the overall indicator. This was due to the addition of some very large and very constant (over time) ”blocks” of the value of household work and leisure. Under a weak sustainability regime one could say that, while the contribution from the environment has gone down, due to e.g. increased leisure time all in all we are better of. But as long as small changes in the doubtful methods of valuation of household work and leisure creates bigger nominal changes in the indicator than the entire environmental correction one should be very careful in using this for policy purposes.

211. Moreover there are serious problems of interpretation related to these measures. Probably more information is lost in aggregation of so many aspects of welfare than is gained.

3.2 Accounting Aggregates Derivable from the SEEA

(provided by Kirk Hamilton, The World Bank, 27 Oct. 1999)

212. Valuation of environmental change is useful in itself, since valuation can feed into decision-making about alternative development strategies and management regimes for environmental assets. This will be true as long as the techniques of valuation attempt to measure the “willingness to pay” of economic agents to obtain environmental services or prevent damages arising from environmental degradation. Under these circumstances, values for environmental change can be directly compared with other economic values in order to guide decisions that maximize social welfare.

213. Valuation within an accounting system is primarily directed, however, at the ability to construct new economic aggregate indicators. The sense that traditional SNA-based national accounts are distorted because they ignore depletion and degradation of the environment is one of the prime motivations for efforts to ‘green’ the national accounts, and the SEEA can contribute substantially to this effort. The fact that important economic assets and liabilities were ignored in the pre-1993 SNA has meant that measures of income and saving have been over-stated, often substantially so, for the most polluted or resource-dependent countries, while wealth has often been understated. By expanding the wealth accounts to include tangible non-produced assets SNA93 has corrected a portion of the problem but, as Hill and Harrison (1995) point out, only incompletely because there is no corresponding adjustment to income and savings.

214. The starting point in deriving accounting aggregates from the SEEA is Hicksian income. SNA93 defines disposable income as “the maximum amount that a household or other unit can afford to spend on consumption goods or services during the accounting period without having to finance its expenditures by reducing its cash, by disposing of other financial or non-financial assets, or by increasing its liabilities” (para 8.15). This measure excludes capital transfers, other changes in the volume of assets, and real holding gains or losses, and is therefore a narrow interpretation of Hicksian income. Hicks (1946) defined income as “the maximum amount which can be spent during a period if there is to be an expectation of maintaining intact the capital value of prospective returns…; it equals consumption plus capital accumulation.”

215. The notion of Hicksian income underpins most economic thinking about income and is embodied in the System of National Accounts. The obvious extension of Hicks into the realm of environmental accounting is to include in “capital accumulation” the changes in value of a wider range of economic assets, including in particular those environmental assets that are scarce and valued by people. Such a definition will exclude some things, such as the value that the environment may yield for other species, but can encompass much of what humans value in the environment.

216. The logical sequence in defining accounting aggregates in the SEEA, therefore, is to first discuss wealth (this will let us classify what capital is being accumulated), then income, then saving.

3.2.1 Wealth

217. The starting point in the SEEA wealth account is simply the balance sheet account from SNA93. This account includes a variety of tangible non-produced assets including land, subsoil assets, non-cultivated biological resources, and water. The key stipulations with regard to these assets are that they occur in nature, and that they have ownership regimes that are enforced and may be transferred (this limits, for instance, which water resources may be valued in the balance sheet accounts). These are sensible stipulations for the SEEA as the basis of a system of *economic* accounts.

218. The SNA balance sheet account therefore covers the potentially depletable resources that are the subject of Chapter 2 of the revised SEEA manual, and any methodologies for valuation of these assets will presumably be shared across accounting systems. The SEEA balance sheet, however, will treat depletion of these resources as a 'change due to transactions' rather than an 'other change in volume' so that there is full linkage between the balance sheet and income accounts in the SEEA.

219. The next question is whether asset values can be placed upon the various aspects and components of environmental degradation linked to pollution. A number of points need to be considered under this heading:

- First, pollution may damage assets that are already measured in the balance sheet account (acid rain may damage buildings or acidify soils, for instance). This suggests that the value of these damages should appear both in the income accounts and in the 'changes due to transactions' portion of the asset accounts linking opening and closing balances.
- Next, the accounts should recognize that there are some environmental assets which are extremely difficult to value *in total*, even though marginal changes in these assets can be valued and indeed should be valued in arriving at an extended Hicksian income measure. The classic example of such an asset is the ozone layer, where extreme uncertainty exists regarding the consequences of a total loss of this asset (what effect would elevated UV radiation levels have on food chains, for instance?), but reasonable marginal values may be derived from estimating excess human cancers resulting from a given loss in ozone layer thickness, then valuing willingness to pay to avoid these cancers.
- A closely related question concerns health status as an asset. It is widely recognized that health status is an important component of human capital and contributor to human welfare, but there is no sensible answer to the question of valuing the total health status of a country as a stock. Again, marginal changes in health status linked to environmental deterioration can be valued (using dose-response methods combined with willingness to pay to avoid a given ailment, or to reduce the risk of death) and arguably should be included in an extended Hicksian income measure.
- Some important stocks are clearly difficult to value both in total and at the margin. Biodiversity is a good example of an asset that is believed to have economic value, but the state of the art in biological science and economics does not permit credible values to be assigned either to the total biodiversity in a given country or region, or to marginal changes in biodiversity.

220. The extended Hicksian framework therefore suggests that the SEEA balance sheet should include tangible non-produced assets and be fully linked to the income account. Many key stocks related to pollution cannot be given sensible values in the balance sheet, but changes in these stocks can be reflected in the income account. This introduces an unavoidable asymmetry in the SEEA accounts. In addition, some stocks cannot be valued either in total or at the margin. In the end the Hicksian framework requires that some pragmatic decisions be made about what can be valued and how completely the income and wealth accounts can be integrated.

3.2.2 Income (EDP)

221. Eco-domestic product or EDP is the income measure derived from the SEEA. The Hicksian framework can be used to give this a precise definition. As suggested above, the key is to include in "capital accumulation" first the standard net investment in produced assets from SNA93 and then the changes in asset values that can be related to the exploitation of natural resources or to pollution exposure.

222. A key point in measuring these changes in asset values 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 in both the asset and income accounts as present values of lost land rents.

The accounting framework for EDP is therefore as follows:

EDP = NDP (GDP – consumption of fixed capital)
- depletion of natural resources (minerals and biological resources)
- "negative land improvements" (excess deforestation)
- pollution damage to economic assets (buildings, forests, soils)
- pollution damage to human health (morbidity and mortality)
- value of increments to stock pollutants (CO_2, ozone layer loss)
- final expenditures on environmental management (including abatement)

Notes on individual items:

- In principle, EDP should measure *net* depletion of biological resources which have an economic value. This implies that this deduction could actually be an addition for those countries where there is net growth in forests, for instance.
- "Negative land improvements" are included as a potential deduction to reflect the fact that incentive policies in many countries (especially in the developing world) can actually distort land conversion decisions to the point where economic asset values decline under the alternative use. So what would normally show up as an investment in land improvement in SNA93 could appear as a net deduction in the SEEA. A complete accounting of the value of natural land conversion would need to derive the "total economic value" of the land under alternative uses, including use

values, option values, existence values, and any production externalities engendered by the natural land (e.g. watershed protection services provided by upland forests).

- Pollution damage to economic assets is in principle captured in the balance sheet accounts of SNA93, but this would require specific damages estimates of a sort that are unlikely within the SNA. Implementing the SEEA can therefore make help to these damages explicit in both the balance sheet and income accounts.
- As noted in the section on wealth, damage to human health is a particularly important change in asset value. Both pollution-linked morbidity and excess mortality need to be valued (using combined dose-response and willingness to pay methods as outlined elsewhere in Chapter 5).
- 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.
- The Hicksian approach treats *final* expenditures on pollution abatement and environmental management as intermediate. This would include protective expenditures by households (e.g. buying filters for tap water).

222a A general issue with regard to accounting for pollution damage is the following:

- Damage caused versus damage borne[1]. SNA93 treats losses due to "unanticipated destruction or disappearance of assets" as other changes in volume, which are therefore not recorded in the income account. To the extent that damages arising from pollutants emitted in other countries are unanticipated (in the sense of not being caused by within-country economic activity), this argues against adjusting income for all damages borne. The corollary would be that adjustments to income should be made for damages caused, since within-country economic activity is the source of this particular form of capital consumption[2].

223. What needs to be kept clear, however, is that the Hicksian approach to income measurement *does not include any attempt to value the flow of the sum of services provided by the environment.* Such a valuation would go beyond the measurement of "consumption plus capital accumulation" and arguably either (i) risks double-counting many benefits provided by the environment that are already measured in GDP (for example tourism expenditures by nature-lovers) or (ii) goes beyond income accounting and into the realm of welfare measurement. Measuring Hicksian income is not equivalent to welfare accounting.

3.2.3 (Genuine) Saving

224. If it were possible in principle and in practice to fully integrate the financial flow and asset accounts of SNA93 and the balance sheet and income accounts of the SEEA, then net saving could be

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[1] SEEA93 refers to 'cost caused and cost borne.' In the present context the terminology of 'damages' rather than 'costs' is more precise.

[2] If it is assumed that other countries have the right not to be damaged by pollution emitted by their neighbours, this logic would dictate that income should in fact be adjusted to reflect damages inflicted on other countries as a result of transboundary pollution.

derived as the reconciling item between these accounts. As discussed above, however, there are certain assets in the environment or linked to environmental quality that cannot be given credible values and so full integration is not possible.

225. 'Genuine' saving in the SEEA should therefore be defined as simply the difference income and consumption by households and governments:

Genuine saving = EDP – C.

The term 'genuine' is employed in order to distinguish this saving measure from the usual SNA93 definition of net saving[3].

3.2.4 Some practical issues

211. Economic aggregates in the SEEA will necessarily be less precise than those in the SNA. While both sets of aggregates depend upon a variety of estimation procedures, the SNA identity is of great importance in limiting the scope of errors in the SNA.

212. Coverage of resources and pollutants that can be valued in the SEEA is likely to be partial for years to come, a fact that should be clearly advertised to users. This can be mitigated to some extent by concentrating on the largest values first (typically depletion for the mineral economies, and damage to human health in the industrial economies).

213. 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 the effect this has on the accounts, and benefits transfer methods offer a possible means to fill gaps where precise local estimates are unavailable.

3.3 Accounting vs. modelling

(No separate text available – see section 1 for a discussion of the issues)

3.4 Institutional arrangements

226. While descriptive economic accounts allow scorekeeping and inform policy making, they cannot stand alone. For instance, they will reveal the impacts of policy only after the fact; ex ante policy analysis or forecasting requires analyses, such as modelling and forecasting, that are beyond the realm of accounting. Thus, there must be a great level of co-operation between those who construct the accounts and those who use them, as the needs of users must be considered in the design of accounts. This co-operation exists in the construction of the conventional economic accounts, and the

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[3] Note that the World Bank uses the term 'genuine saving' to include investments in human capital formation. This is achieved by 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.

same must be achieved for extended economic-environmental accounts. Indeed, given the relative scarcity of data available for the construction of integrated economic-environmental accounts, there must be an even greater level of co-operation. Even the measurement of physical quantities or of degradation and improvements of natural resources and environmental assets is more complicated than the measurement of marketed economic goods and services; the measurement must be informed by experts–biologists, environmentalists, etc.–in the area in question. Further, as mentioned above, in many cases preferences must be determined outside of the descriptive accounts.

227. What types of institutional arrangements are needed for the successful construction and use of integrated economic-environmental accounts may vary from country to country, depending on the types of existing institutions. In countries where policies and the statistics that inform them are centralised in single agencies, co-operation may occur naturally; other countries where statistical agencies and policy agencies are maintained separately may benefit from the establishment of advisory panels made up of the users of statistics as well as experts in the various fields of information needed for the construction of statistics.