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SEEA Experimental Ecosystem Accounts

Chapter 2: Principles of ecosystem accounting

(for discussion)

REVISION OF THE SYSTEM OF ENVIRONMENTAL - ECONOMIC ACCOUNTING (SEEA)

SEEA Experimental Ecosystem Accounts

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DRAFT

Chapter 2: Principles of ecosystem accounting

Material prepared in consultation with the Editorial Board for the SEEA Experimental Ecosystem Accounts and following discussions at the Expert Meetings on Ecosystem Accounts.

The following text has been drafted for discussion among UNCEEA members as part of the process of developing the SEEA Experimental Ecosystem Accounts. The material should not be considered definitive and should not be quoted.

Status of Chapter 2

Chapter 2 is an important chapter that sets the scene for the basic relationships between the parts of the ecosystem accounting framework. Although ongoing discussion will continue to refine the model and the description of it, on the whole there is a clear convergence that is emerging. As for other parts of the SEEA Experimental Ecosystem Accounts, it will be necessary to test the framework with a wider range of stakeholders.

While the general model is developing well, there remain some particular areas in which further work is required. These areas concern the description of ecosystems from an ecological perspective, the treatment of marine ecosystems and the atmosphere in the context of ecosystem accounts, and the appropriate classifications for the statistical units model for ecosystems that has been developed.

Chapter 2: Principles of ecosystem accounting

Table of contents

2.1 Characteristics of ecosystems

2.2 Key conceptual relationships in ecosystem accounting

2.3 Statistical units for ecosystem accounting

2.4 General measurement issues in ecosystem accounting

2.5 Relationship of SEEA Experimental Ecosystem Accounts to the SNA and the SEEA Central Framework

2.1 Characteristics of ecosystems

2.1 Ecosystems are a dynamic complex of biotic communities interacting with their non-living environment. They change both as a function of natural processes (e.g. succession, natural disturbances such as a storm) and because of human actions (either through deliberate management or through human disturbances such as the extraction of natural resources or the introduction of invasive exotic species).

2.2 Traditionally, ecosystems were associated with more or less ‘natural’ systems, i.e. systems with only a limited degree of human interference. However a wider interpretation has become more common, based on the recognition that human activity influences ecosystems across the world. Thus, agricultural land is also considered as being an ecosystem providing different types of benefits (e.g. crop production, carbon sequestration, supporting tourism and recreation).

2.3 In ecosystems, different degrees of human management and control can be observed. For instance, in a natural forest or a polar landscape, ecological processes dominate the dynamics of the ecosystem. At the other end of the spectrum, in a greenhouse or in intensive aquaculture ponds, ecological processes have become dominated by human management.

2.4 Key aspects of the operation of an ecosystem are (i) its structure (e.g. the food web within the ecosystem), (ii) its composition, including biotic (flora and fauna) and abiotic (soil, water) components, and (iii) its processes (e.g. photosynthesis or the recycling of nutrients in an ecosystem). Another structural feature of ecosystem, related to its composition, is the species and genetic diversity contained in the ecosystem.

2.5 Ecosystems can be identified at different spatial scales, for instance a small pond may be considered as an ecosystem, as may a tundra ecosystem stretching over millions of hectares. In addition, ecosystem are interconnected and sometimes overlapping, and they are subject to ecological and environmental process that operate over varying time scales.

2.6 For the purposes of developing an ecosystem accounting approach in the SEEA, a somewhat narrower definition of ecosystems is applied such that there is a linking of ecosystems to spatial areas and a more specific recognition of the key aspects of ecosystem functioning. Thus, in the SEEA, ecosystems are areas containing a dynamic complex of biotic communities (for example plants, animals and micro-organisms) and their non-living environment interacting as a functional unit through a combination of ecosystem structures, composition, and processes.

2.7 It is now widely recognised that ecosystems are subject to complex dynamics including such aspects as irreversible responses to stress and multiple steady states. The propensity of ecosystems to withstand change, or to recover to their initial condition following disturbance is called ecosystem resilience. The resilience of an ecosystem is not a fixed, given property, but may change over time, for example, due to degradation. These complex dynamics make the behaviour of ecosystems as a function of management and natural disturbances difficult to predict.

2.8 In this context, ecosystem accounting can only provide a specific representation of ecosystems and cannot provide a complete model of internal ecosystem flows and broader ecosystem interactions. All of the accounting structures presented in the SEEA Experimental Ecosystem Accounts are thus necessarily an abstraction from an ecological reality.

2.2 Key conceptual relationships in ecosystem accounting

2.9 In common with all accounting systems, ecosystem accounting is founded on relationships between stocks and flows. The stock in ecosystem accounting is represented by *ecosystem capital*. The flows are of two types. First, there are flows that reflect that society takes advantage of a multitude of resources and processes that are supplied by ecosystems – collectively these are known as *ecosystem services.* Second, flows are recorded to account for changes in ecosystem capital over an accounting period either due to *natural processes* or due to human intervention (both positive and negative) in the ecosystem.

2.10 The description of the relationships presented here is formed from consideration of the ecosystem and its relationship to the economy in non-monetary or physical terms. The detailed discussion of measurement in physical terms is presented in Chapters 3 and 4. The set of relationships can also be measured in monetary terms without changing the underlying logic of the relationships between ecosystem capital, ecosystem services and benefits. At the same time, the measurement and accounting issues involved in compiling data in monetary terms are somewhat different from those involved in measurement in physical terms. Approaches to the valuation of ecosystem services is considered in Chapter 5 and accounting structures related to estimates in monetary terms are discussed in Chapter 6.

Ecosystem services

2.11 Ecosystem services are at the hub of the ecosystem accounting model. Flows of ecosystem services provide the link between ecosystem capital on the one hand, and the benefits received by society on the other. Hence they are at the intersection of the relationship between ecosystems and society which is the focus of ecosystem accounting.

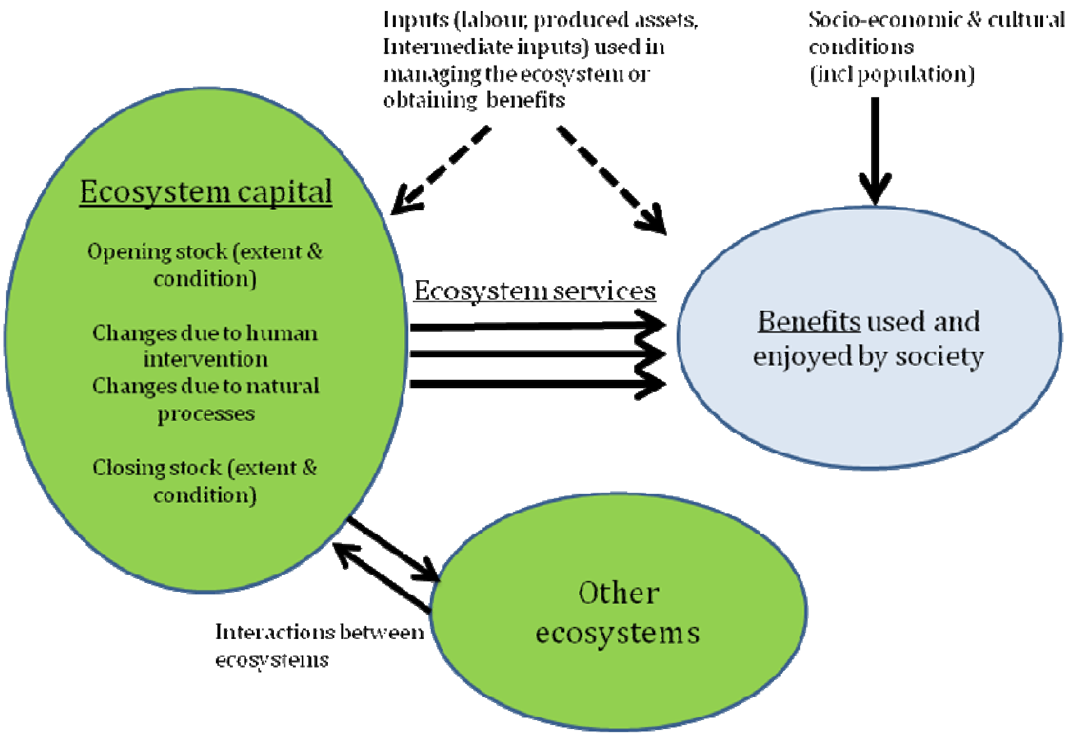
2.12 A range of definitions for ecosystem services have developed and used in various contexts from site specific case studies to large national and global assessments of ecosystems. Often the basic concept of ecosystems supplying resources and processes that are of use to society can be lost in different interpretation of terms. At the same time, the formulation of a definition of ecosystem services is an essential ingredient for measurement purposes.

2.13 The starting point in defining ecosystem services for the purposes of ecosystem accounting is the understanding that people benefit (i) from the materials that can be harvested from an ecosystem (such as the harvesting of timber from forests); (ii) from natural processes (such as the benefits from clean air that has been filtered in the environment); and (iii) from their interaction with nature (such as benefits from recreation). Together these various types of benefits contribute to overall human well-being and welfare, noting that benefits and well-being are not synonymous. The different types of benefits may be ones that emerge from the economic activity of enterprises, governments and households (including, for example, subsistence farming), or they may be directly enjoyed by individuals and society as a whole.

2.14 Importantly, not all of the resources and processes that occur in an ecosystem give rise to benefits. Thus, for accounting purposes, there is a boundary that must be recognised that reflects the connection between the full array of resources and processes of the ecosystem and the benefits that are obtained. This boundary is defined by the concept of final ecosystem services – i.e. the sub-set of resources and processes of an ecosystem that contribute to benefits received by society. The remaining resources and processes are considered to supply "intermediate" or "supporting" ecosystem services within the ecosystem or between ecosystems.

2.15 The basic structure for ecosystem accounting is therefore a staged process whereby (i) an ecosystem has a mix of resources and processes; (ii) some of these resource and processes are supplied to society (final ecosystem services); (iii) these final ecosystem services contribute to benefits used or enjoyed by society, and (iv) the benefits are used in the satisfaction of well-being. Thus, within this structure ***ecosystem services are the contributions of ecosystems to benefits used or enjoyed by society.***

Figure 2.1 The core ecosystem accounting structure



2.16 Figure 2.1 reflects this staged structure that underpins the ecosystem accounts. Several aspects of the figure must be highlighted. First, in the context of ecosystem accounting, society comprises households, individuals, enterprises and governments. This scope recognises that the beneficiaries in ecosystem accounting comprise all people and social structures within society.

2.17 Second, some benefits arise only as a result of production processes undertaken by enterprises, households or government. The harvesting of natural resources is the most straightforward example. In these situations, the benefits are not purely a function of ecosystem services. In addition, a range of inputs – such as labour, produced assets and intermediate consumption (e.g. fuel) – are also used. These inputs must be taken into account in determining the flow of ecosystem services.

2.18 Third, some benefits arise that are not the direct result of production processes. Since for an ecosystem service to be recorded there must be beneficiaries (i.e. people), in these situations, the extent of recording of an ecosystem service will be dependent on the number and location of people in relation to an ecosystem. Generally speaking, increases in the number of people will increase the flow of ecosystem services and the related flow of benefits.

2.19 Fourth, in the vast majority of situations, people intervene in ecosystems and affect the flow of ecosystem services. This may involve deliberate actions, such as laying down access roads, shaping the land to control water flows, or limiting access to certain areas. In other cases the flow of ecosystem services may be affected by the nature of economic activity, such as via deforestation or pollution. In ecosystem accounting these interventions and effects are recorded as changes (both positive and negative) in ecosystem capital.

2.20 A fundamental aspect of ecosystem accounting is recognition that a single ecosystem will generate a range of ecosystem services thus contributing to the generation of a number of benefits. In some cases the benefits may be produced "in tandem", such as when forest areas are preserved and provide benefits in terms of clean air and opportunities for recreation and hiking. In other cases the benefits may be in competition, such as when forest areas are logged thus providing benefits of timber but losing benefits of recreation. The ability to examine these trade-offs is an important part of ecosystem accounting.

2.21 A classification of ecosystem services has developed in recent years and three main types of ecosystem services are recognised namely, provisioning services, regulating services and cultural services. The Common International Classification of Ecosystem Services (CICES) is presented in Chapter 3. It provides additional detail on the types of services that comprise the measurement scope.

2.22 Excluded from the scope of ecosystem services are so-called "intermediate" or "supporting" services. It is recognised that there are many processes that take place within ecosystems and often the observed contribution of an ecosystem is only the final link in a chain of integrated steps. In order to avoid overstating the contribution of ecosystems, only the final link is included in ecosystem services as defined in the SEEA. This choice also accepts that a full articulation of all ecosystem processes is currently not possible.

2.23 At the same time, it is important that all of the flows associated with intermediate services are recorded within the accounting framework. This is done as part of accounting for changes in ecosystem capital between the beginning and end of the accounting period.

Benefits in ecosystem accounting

2.24 The benefits received by society may be characterised in a number of ways. First, they may be considered as either individual or collective benefits. Following standard economic principles, collective benefits (commonly referred to as "public goods")[1] are those benefits which exhibit

[1] The term "collective" is used to distinguish the type of benefits from the economic units that are commonly responsible for their delivery. The term public goods may be interpreted as all services provided by governments

non-excludability (i.e. it is not possible to deny people the benefits), and non-rivalry (i.e. one person's enjoyment of a benefit does not diminish the availability of the benefit to others). Clean air is a typical example of a collective benefit.

2.25 Second, some benefits emerge from production processes within the scope of the production boundary defined by the System of National Accounts that underlies the measurement of key economic aggregates such as Gross Domestic Product. By convention these benefits are referred to as material benefits. Those benefits that arise outside production processes as defined in the SNA are referred to as non-material benefits. For non-material benefits, the benefit received by society is, in measurement terms, equivalent to the flow of ecosystem service. The distinction between material and non-material benefits is drawn to aid in the description of the relationship between the ecosystem accounts and the accounts of the SNA.

2.26 The scope of benefits in the SEEA does not extend to the broader notion of wellbeing or outcomes that may arise as a result of consumption and use of the benefits (for example, healthy diets or improved quality of life). While these outcomes may indeed be of interest, their measurement is outside the scope of ecosystem accounting.

Ecosystem capital

2.27 ***Ecosystem capital is the capacity for ecosystems to generate ecosystem services.*** The measurement of ecosystem capital is undertaken within an asset accounting framework that records the capacity at the beginning of an accounting period (opening stock of ecosystem capital), the capacity at the end of the accounting period (closing stock of ecosystem capital) and the changes between those points in time. The measurement of ecosystem capital is not direct however and must consider both changes in the extent or quantity of the ecosystem (for example in terms of the area of a particular ecosystem), and changes in the condition or quality of an ecosystem. Ecosystem capital is thus a function of both extent and condition.

2.28 The capacity of an ecosystem to generate ecosystem services must be based on the current set of ecosystem services being generated by an ecosystem and on expectations regarding how that set of services may continue to be provided given current infrastructure, patterns of consumption and production, and social contexts. The assessment of expected ecosystem service flows must take into account the ability of ecosystem processes to continue effectively, for example in terms of the ability of trees to regenerate and for soils to retain their productivity.

but, in fact, many of these services are individual in nature (such as health and education). Thus a clear distinction must be made between collective benefits and the non-marketed output of governments.

2.29 Measurement focus should not be placed on the set of ecosystem services that might be generated if alternative technologies, economic arrangements and social contexts existed. Using an accounting framework, such scenario building and assessment can be undertaken but it is not strictly accounting as described in the SEEA.

2.30 As an example of the measurement of ecosystem capacity, the capacity of a forest available for felling would need to take into consideration the ability for the forest to continue to produce timber for felling in balance with all other ecosystem services. In this situation, for the forest as a whole, felling in excess of natural growth of timber would imply a loss in capacity.[2] At the same time, the capacity of a forest protected from felling that is able to provide other ecosystem services (such as air filtration and recreational services) should not be assessed in relation to the potential for the timber in the forest to be felled if there is no reasonable expectation that this will happen.

2.31 Changes in ecosystem capital are due to either natural processes or human intervention in the ecosystem. Natural processes cover a wide range of flows reflecting the dynamic nature of ecosystems and the wider environment. Both short term and long term natural processes are included as part of these flows. Also included are changes considered to be regular and those that may be considered more extreme and infrequent (such as changes caused by earthquakes).

2.32 Human intervention in ecosystems may take a variety of forms. Most commonly considered are situations in which economic units alter the ecosystem in order to extract resources (such as timber, fish and water), or to shape the landscape to provide a basis for economic activity (such as settlement, agriculture or recreation). In making these interventions, economic units will use inputs such as labour, produced assets and other intermediate inputs.

2.33 Human intervention may lead to an ecosystem type changing completely (e.g. from forest to agricultural land as a result of deforestation). These changes should be recorded as reclassifications between ecosystem types. For a country or region as a whole such changes should be accounted for in changes in the measures of the extent of different ecosystem types since the total area is likely to be relatively unchanged.

2.34 Human intervention may also be targeted to the restoration of ecosystems. This may be through the direct investment of economic inputs or, more indirectly, by restricting the use of certain areas and allowing natural processes to rebuild the local environment.

[2] Indeed, depending on the nature of the felling practice even felling equal to natural growth may imply a change in capacity depending on the impacts on the delivery of other ecosystem services. It is also noted that there may be longer term impacts on ecosystem functioning from ongoing felling even if, using simple indicators, the rates of felling and natural growth are balanced.

2.35 Generally, much focus in the measurement of changes in ecosystem capital is on whether an ecosystem has degraded over an accounting period. In ecosystem accounting the general concept of degradation is measured in terms of *consumption of ecosystem capital* (CEC). ***Consumption of ecosystem capital is the reduction in the capacity of an ecosystem to provide ecosystem services that is due to human activity.*** It may be due to a loss of the extent of an ecosystem, or due to a loss of condition, or some combination of the two.

2.36 Since ecosystems may, in many situations, restore themselves if given the opportunity, it may be considered that consumption of ecosystem capital should only be recorded when the capacity of an ecosystem has reached a point of irreversibility. However, from an accounting perspective, it is relevant to record reductions in capacity on an ongoing basis and thereby provide information that can be assessed in relation to thresholds. Thus all reductions in capacity due to human activity over an accounting period are treated as consumption of ecosystem capital irrespective of whether the ecosystem may, potentially, restore itself.

2.37 Further, it is noted that the relevant human activities need not only relate to the accessing of ecosystem services. Human activity in ecosystems may take many forms including the development of mining operations, the expansion of housing developments, the building of roads, etc., and these will generally reduce the capacity of an ecosystem to generate ecosystem services – or, indeed, completely change the ecosystem itself. Effects may be also be conceptualised in terms of human "inactivity" through a lack of maintenance and protection of ecosystems. Finally, it is also possible for the impacts to arise from human activity in other countries or regions. All of these human impacts should be considered as forming a basis for the estimation of consumption of ecosystem capital.

2.38 Consumption of ecosystem capital differs from degradation as commonly understood by not including all possible changes in the capacity of an ecosystem over an accounting period. Thus, changes due to natural processes, for example the loss of timber resources due to naturally occurring bushfires, is not included in measures of consumption of ecosystem capital. By defining consumption of ecosystem capital in this way a direct comparison can be made to measures of consumption of fixed capital (commonly referred to as deprecation) which is defined as the fall in value of produced assets due to ongoing use of the assets in production.

2.39 Significantly, the existence of a flow of ecosystem services does not imply consumption of ecosystem capital. It is quite possible for ecosystem services to be generated with no capital consumption occurring (e.g. air filtration services from a protected forest). Further, it is possible for the consumption of ecosystem capital to occur even while a constant stream of ecosystem services is being recorded. Thus, it is essential in ecosystem accounting that the measurement of ecosystem services flows is clearly distinguished from measurement of changes in ecosystem capital. This is achieved through the development of separate accounts for ecosystem services and ecosystem capital.

2.3 Statistical units for ecosystem accounting

2.40 In order to undertake measurement of ecosystems in a co-ordinated way and to subsequently compare and analyse information across time and between ecosystems, there must be a clear focus for measurement. Boundaries between ecosystems are generally drawn on the basis of relative homogeneity, in terms of composition, processes and/or structure, and in terms of having stronger internal functional relations than external ones. However, these boundaries are often gradual and diffuse and the specific boundary between two ecosystems may be difficult to establish. Further, ecosystems may be very small or very large and operate at different spatial scales.

2.41 Following standard statistical practice, statistical units are defined for ecosystem accounting. These statistical units represent the focus for measurement and for the organisation of information. Ideally, statistical units should be ecologically and economically relevant, policy relevant, meaningful from a statistical perspective and, finally, relatively commonly understood. In order to meet these various objectives the approach taken in the SEEA is to describe different types of statistical units that together form a units model that can be used for different purposes, including compilation, reporting and analysis.

Statistical units model in the SEEA

2.42 The conceptual basis for the statistical units model in the SEEA starts with a *basic spatial unit* (BSU) which is formed by partitioning the area of interest (for example a region or country) on a spatial basis. This can be done by delineating tessellations, most typically by overlaying a grid on a map of the relevant territory. Ideally the grid squares - each one being a BSU – are as small as possible with the scale being chosen based on available information and the degree of diversity in the landscape. Alternative units models that are not spatially based may also be developed for specific purposes.

2.43 Each BSU should be attributed with a basic set of information. The most common starting point for this attribution process will be information on the location of the unit and land cover. This basic information is then extended with information relevant to the purpose of the account being compiled. For example, relevant information may include soil type, groundwater resources, elevation and topography, climate and rainfall, biodiversity, the degree of connection to related areas, current land uses, location relative to human settlement, and the degree of accessibility to the area by people.

2.44 This range of information recognises that while each BSU is a mutually exclusive area, it exists within a number of systems that operate at varying spatial scales. In particular, it is recognised that measuring the provision of different ecosystem services requires assessing factors outside of a given BSU but then attributing to the BSU the results of that assessment. For example, the relative position or connectivity of the BSU within its broader landscape may be useful information.

2.45 Using the information attributed to the BSUs, the next level of statistical unit, referred to as the *ecosystem accounting unit* (EAU) may be delineated. For most terrestrial areas an EAU is defined as the set of contiguous BSUs satisfying a pre-determined set of factors, for example the BSUs of a particular land cover type or those relevant to the delivery of a specific ecosystem service. Following standard approaches to statistical classification, BSUs would be classified to particular EAUs on the basis of a pre-dominance of characteristics.

2.46 In practice, the most basic way to apply this conceptual model is by splitting the area (i.e. the region or country) into generic types of land cover, land use, habitat or biomes. An example of a generic set of types of EAU that might be used for this purpose are the land cover types shown in Table 2.1 or the types of biomes that have been used in the Convention on Biological Diversity. If more information is available or more detailed accounts are required it is possible to apply the units model in a more detailed fashion.

2.47 When compiling an account for an entire country or administrative region each underlying BSU should only be classified to one EAU. However, if more specific topics were of interest (for example, accounting for particular ecosystem services) it would be possible to define EAU using different combinations of BSUs perhaps taking into account different types of information.

2.48 The size of the EAUs may vary substantially depending on the relative homogeneity of the landscape, the size of the region or country, and other related factors. Some degree of smoothing may be required to restrict the number of EAUs to a workable number. It should be recognised that where only a limited amount of information is available to delineate EAUs there will remain a lack of homogeneity within a single type of EAU for a country in terms of soil type, rainfall, elevation, hydrology, etc. This extensive spatial variability has a particular impact on the supply of ecosystem services. In addition, flows such as consumption of ecosystem capital will vary spatially. As far as possible this spatial variation needs to be accounted for and the link between ecosystem capital and the delivery of ecosystem services needs to be clearly articulated.

Table 2.1 Land Cover Types (SEEA Central Framework, Chapter 5.6)

	Category
	Artificial surfaces (including urban and associated areas)
	Herbaceous crops
	Woody crops
	Multiple or layered crops
	Grassland
	Tree covered areas
	Mangroves
	Shrub covered areas
	Shrubs and/or herbaceous vegetation, aquatic or regularly flooded
	Sparsely natural vegetated areas
	Terrestrial barren land
	Permanent snow and glaciers
	Inland water bodies
	Coastal water bodies and inter-tidal areas

2.49 To this end, the development of statistical units should be undertaken in concert with the development of spatial databases in Geographic Information Systems (GIS). These databases should contain ecological information such as soil type and status, water tables, rainfall amount and pattern, temperatures, vegetation, biodiversity, slopes, altitude, etc., as well as, potentially, information on land management and use, population, and social and economic variables. Combined, this information may be used to assess flows of ecosystem services from given spatial areas.

2.50 The EAU may be aggregated into larger statistical units as required for analytical or reporting purposes. However, the EAU is the central ecosystem accounting statistical unit as it represents the spatial area for which all relevant information should be integrated. Thus, where possible, information that may be available at higher levels of spatial aggregation should be downscaled to the EAU level and information available at finer spatial scales should be aggregated.

2.51 There is a range of different types of larger statistical units to which EAUs may be classified but there is no single classification of these larger units. The choice of classification depends on the information that is available in countries and the policy and analytical questions of interest. Examples of larger statistical units include river basin and catchment areas, areas based on soil types, and areas that define socio-ecological systems.[3]

2.52 This approach to defining statistical units for ecosystem accounting is consistent with an approach in which ecosystems are defined in relation to spatial areas but in turn recognises that different ecosystems operate at different spatial scales.

2.53 Further consideration is needed to define EAUs that take into account rivers, coastal areas and marine environments. Nonetheless, this conceptual units model can be applied in these instances.

2.54 In practice, when applying this conceptual units model for policy and reporting purposes, there may be a direct interest in understanding information about ecosystems at the level of an administrative region – which in many cases may not conform neatly to a set of EAU defined from an ecosystem perspective. Therefore an approach might be used where the relevant spatial area for statistical purposes is defined by politically established boundaries or, perhaps land management boundaries. While landscape features may well have been taken into account in setting these boundaries, other factors are also likely to have come into play. It is noted, for example, that administrative boundaries may commonly be defined by large rivers and waterways thus creating a boundary that may not be meaningful from an ecosystem perspective.

2.55 Having defined a spatial area for policy and reporting purposes in this fashion, it is likely that it will contain a range of areas that have different characteristics in terms of ecosystem capital and ecosystem services. At this point, it may be useful to split the area using EAU constructed with a generic set of "ecosystems", for example using the types of biomes that have been used in the Convention on Biological Diversity and in the context of the Millennium Ecosystem Assessment.

Relationship to economic classifications

2.56 The cross-classification of EAU information with economic units is central to assessment of the relationship between ecosystem services, ecosystem capital and economic activity. The application of ecosystem related information to questions of land management and consumption of ecosystem capital requires such links to be made.

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[3] "Socio-ecological systems integrate ecosystem functions and dynamics as well as human activities and the interactions of all these." From "An Experimental Framework for Ecosystem Capital Accounting in Europe", *European Environment Agency Technical Report No 13/2011*, EEA 2011, page 12.

2.57 Ideally, the linking of EAU to economic units would be undertaken in the process of attributing BSUs with basic information on, for example, land use or ownership (cadastres). If this detailed linking is not possible then broader assumptions may be used for example by linking information on land cover and land use to EAUs.

2.58 It is noted that the beneficiaries of the ecosystem services may be the land user or owner, or, it may be people living nearby (as in the case of air filtration) or society at large (as in the case of carbon sequestration). Further, in specific cases the beneficiaries can be spatially delineated, such as in the case of people living downstream in the flood zone of an upper catchment that is managed with the aim of protecting its hydrological services.

Additional information

2.59 An annex to SEEA Experimental Ecosystem Accounts provides a summary of relevant methods and other measurement considerations in the establishment of statistical units.

2.4 General measurement issues in ecosystem accounting

2.60 This section introduces some of the general measurement issues that may arise in the compilation of ecosystem accounts. They are primarily practical issues but are important considerations in setting up a framework for ecosystem accounting following the general model outlined in this chapter.

2.61 The measurement issues discussed in this chapter concern (i) the integration of information across different spatial scales, (ii) the length of the accounting period, and (iii) the use of reference conditions.

The integration of information across different spatial scales

2.62 The objective of ecosystem accounting in the SEEA is the development of information sets for the analysis of ecosystems at a level suitable for the development of public policy. Consequently, consideration must be given to collecting and collating information pertaining to a range of ecosystems across a region or country. Following standard statistical practice, the central element in the integration of information is the establishment of statistical units. The statistical units model for ecosystem accounting of basic spatial units (BSU) and ecosystem accounting units (EAU) should provide a comprehensive coverage of areas within a country.

2.63 The information used to characterise statistical units provides important data that can be used to aggregate and disaggregate across statistical units. For example, BSUs may be attributed with standard variables such as area, rainfall, and elevation, in addition to being classified to a particular land cover type. Consequently, different statistical units of the same land cover type may be constructed, compared and differentiated through consideration of these types of variables. For example, high rainfall and low rainfall forest may be compared. Alternatively, the area of EAUs may be used for aggregation purposes, such as accounting for large contiguous areas of grassland compared to fragmented or isolated areas.

2.64 This approach is analogous to the definition of statistical units for economic statistics. Economic units are commonly characterised by the number of people employed in addition to being classified to a particular industry. Thus, when aggregating across economic units it is possible to take into account not only the type of activity but also whether the unit is relatively large or small.

2.65 Ideally, it should be possible to produce a register of EAUs for each accounting purpose containing standard information about these units. This may be possible from the use of remote sensing information, administrative data on land management or from land based surveys of land cover and land use.

2.66 Where data gaps exist in terms of ecological, land use and socio-economic data, there is potential to use these "unit registers" to design sample surveys for ecosystem accounting purposes in which the samples take into account the different characteristics. In statistical terms, different groupings (or strata) of EAUs could be designed and the characteristics would also form the basis for aggregations. For example, groups of EAU related to the water cycle could be constructed with information about catchments, floodplains, wetlands and rivers.

2.67 The application of such standard statistical approaches to the integration of information is likely to abstract from the specific realities within individual ecosystems. However, in principle, this is no different from the abstractions that take place within the compilation of national level household and business statistics using sampling approaches.

2.68 In practice however, it is likely that more understanding is needed of the operation of individual ecosystems in order to find the right set of standard variables that can be used to compare and contrast ecosystems for the purposes of higher-level analysis. Consequently, a considerable degree of caution should be used in assuming that the characteristics of one statistical unit can be easily applied in another statistical unit, even if they have the same land cover type.

2.69 The SEEA recommends that a rigorous description of statistical units following standard statistical practice be undertaken before an aggregation of information to regional or national levels takes place.

2.70 In many situations it may be necessary to attribute national or regional level information to particular statistical units. This process is generally referred to as “downscaling”. Again, the effectiveness of downscaling techniques will be considerably enhanced through the development of a comprehensive set of information on different statistical units across a region or country.

Length of the accounting period

2.71 In economic statistics there are clear standards concerning the time at which transactions and other flows should be recorded and the length of the accounting period. The standard accounting period in economic accounts is one year. This length suits many analytical requirements (although often quarterly accounts are also compiled) and also aligns with the availability of data through business accounts.

2.72 While one year may suit analysis of economic trends, analysis of trends in ecosystems may require information of varying lengths of time depending on the processes being considered. Even in situations where ecological processes can be analysed on an annual basis the beginning and end of the year may well differ from the year that is used for economic analysis.[4]

2.73 Although considerable variation in the cycles of natural processes exists, it is recommended that ecosystem accounting retain the standard economic accounting period length of one year. Most significantly, this length of time aligns with the common analytical frameworks for economic and social data and, since much economic and social data are compiled on an annual basis, the general integration of information is best supported through the use of this time frame.

2.74 Consequently, for the purposes of compiling ecosystem accounts, it may be necessary to convert or adjust available environmental information to an annual basis using appropriate factors or assumptions.

2.75 Measures of the extent, condition and capacity of ecosystems and their components should relate to the opening and closing dates of the associated accounting period. If information

[4] For example hydrological years may not align with calendar or financial years.

available for the purposes of compiling ecosystem capacity accounts does not pertain directly to those dates then adjustments to the available data will be required.

The use of reference conditions

2.76 Measures of the condition of an ecosystem at a particular point in time necessarily require an assessment of the ecosystem in relation to either another ecosystem or, more commonly, in relation to the condition of the same ecosystem at an earlier point in time. The general feature of these assessments is that, although they are expressed in quantitative terms, a degree of subjectivity is necessarily involved in determining the extent to which quality has changed. For example, comparing an ecosystem against a condition in a previous year involves selecting a reference year.

2.77 The choice of a reference condition for assessing ecosystem condition may imply certain views on the preferred state of the ecosystem. For example, if the reference condition is based on how an ecosystem would function with less or without human intervention, then most ecosystems that are subject to human intervention will be measured as being of lower quality. In turn, this may suggest that the appropriate response is to restore the ecosystem to a quality that would exist without human intervention. While these conclusions need not be drawn from the choice of such a reference condition, it is clear that the choice of reference condition must be done with caution.

2.78 In addition, it needs to be considered that it is the combination of ecosystem types and uses that provides society a bundle of ecosystem services (food, water regulation, opportunities for recreation, nature conservation). Analysing the services supplied by only one ecosystem without consideration of the societal and ecological context may not always provide meaningful information.

2.79 In order to limit the extent to which implications for management objectives might affect the interpretation of information in ecosystem accounts, the preference in the SEEA is to measure changes in condition (i.e. quality) from the beginning of the accounting period. Thus, when compiling accounts for any given accounting period, the measure of quality change should refer to the change from the beginning of the period to the end. This is sufficient for accounting purposes and also aligns with the general approach used in the measurement of quality change in economic statistics.

2.80 A variation to this approach would be to retain a single reference condition that is used from the commencement of a time series of ecosystem accounts. That is, for example, retaining the same reference condition for a five year time series of ecosystem accounts.

2.81 The approach to reference conditions in the SEEA is different from determining changes in condition and quality by comparison to policy objectives or targets. For accounting purposes it is not appropriate to take a position on relevant objectives and targets for ecosystem condition and capacity. However, once a core set of information is available within an accounting framework, analysis of different objectives and targets is possible. One option might be to consider the implications of different policy objectives for different ecosystems to assess relative costs and benefits.

2.5 Relationship of SEEA Experimental Ecosystem Accounts to the SNA and the SEEA Central Framework

Relationship of ecosystem accounts to the SNA

2.82 The accounting approach outlined in the SEEA Experimental Ecosystem Accounts is founded on the accounting approach described in the SNA. However, there are a range of extensions and re-presentations of core SNA concepts that are used. This section outlines these differences.

2.83 The first main difference concerns the scope of benefits considered in ecosystem accounting compared to the SNA. In the SNA the initial focus of accounting is on the outputs from production processes that combine capital, labour and other inputs (such as fuel and materials). These outputs are goods and services – collectively referred to as products. In turn products are consumed or accumulated by economic units. In ecosystem accounting, the benefits include some products within scope of the SNA (such as timber and fish harvested from ecosystems) but also include a broad range of collective benefits from ecosystems (such as clean air) and some individual benefits (such as the amenity benefit of landscapes).

2.84 It is clarified that the production of goods on own-account (for example, the outputs from subsistence farming and fishing, the collection of firewood and water for own-use, and the harvest of naturally occurring products such as berries) is all within scope of the production boundary defined in the SNA and within scope of the benefits recorded in the SEEA ecosystem accounts. The extent to which countries include the production of goods on own-account as part of their measures of GDP may vary however.

2.85 The second main difference concerns the approach to defining the scope of assets. In the SNA, the scope of assets is limited to those assets that have economic value by virtue of being expected to deliver a stream of benefits to the owner or user of the asset in the future. The stream of benefits in this case is limited to income from production, income from allowing the use of an asset in production (e.g. rent earned on allowing the use of land) and earnings from the sale of an asset. In the last two cases the benefits are limited to those evidenced by a monetary transaction. A consequence of this approach is that a range of bio-physical assets are excluded from scope because they do not have an identified stream of SNA benefits.

2.86 In the SEEA Experimental Ecosystem Accounts, the set of benefits is broader. This has two primary consequences, first, a broader range of bio-physical assets are included relative to the SNA since all parts of the bio-physical aspects of a country are considered to contribute to the extended set of benefits. Thus, for example, all land is included in scope of the ecosystem accounts irrespective of whether it has a value in monetary terms following SNA principles. Second, the recognition of a broader set of benefits implies, assuming valuation is possible, that the value of a given asset in monetary terms (e.g. a forest) will be different, quite possibly higher. In these senses the asset boundary of the SEEA Experimental Ecosystem Accounts is broader than the SNA.

2.87 For biological resources (e.g. timber, fish, livestock, orchards, etc) the SNA makes a clear distinction between cultivated and natural resources. Cultivated biological resources are considered outputs from production processes whereas natural biological resources are considered flows from the environment which are inputs to the production process only when harvested. Since cultivated biological resources are products, their accounting treatment is quite different from natural resources.

2.88 In the SNA, the boundary between cultivated and natural biological resources is defined following general principles concerning the degree of management that is exerted by economic units over the growing of the associated animals and crops. High levels of management imply the resources are cultivated. In practice, the boundary may be difficult to determine.

2.89 In SEEA Experimental Ecosystem Accounts, as in the SEEA Central Framework, the scope of environmental assets in general, and ecosystems in particular, includes both cultivated and natural biological resources. In the case of the SEEA Central Framework this allows a more complete assessment of the stock of particular types of resources, for example timber resources or aquatic resources. In the case of SEEA Experimental Ecosystem Accounts, the motivation to include both cultivated and natural resources is more refined. For ecosystems it is more relevant to consider the intensity of use of an ecosystem and the extent to which there is management of targeted species. At the same time, recognising that few if any ecosystems remain that are not managed for influenced by people, it is difficult to observe purely natural ecosystems and all ecosystems may be considered “cultivated” to some degree. Consequently, rather than attempt to distinguish between ecosystems on the basis of whether they are cultivated or natural, all ecosystems are considered jointly.

Relationship of ecosystem accounts to the SEEA Central Framework

2.90 The SEEA Central Framework consists of three broad areas of measurement (i) physical flows between the environment and the economy, (ii) the stocks of environmental assets and changes in these stocks; and (iii) economic activity and transactions related to the environment. The ecosystem accounting described in the SEEA Experimental Ecosystem Accounts provides additional perspectives on measurement in these three areas.

2.91 First, the SEEA Experimental Ecosystem Accounts extend the range of flows measured in quantitative terms. The focus in the SEEA Central Framework is on the flows of materials and energy that either enter the economy as natural inputs or return to the environment from the economy as residuals. Many of these flows are also included as part of the physical flows recorded in ecosystem accounts (e.g. flows of timber to the economy). In addition, the SEEA Experimental Ecosystem Accounts includes measurement of the individual and collective benefits that arise from ongoing ecosystem processes (such as the regulation of climate, air filtration and flood protection) and from human engagement with the environment (such as through recreation activity).

2.92 There are a number of natural inputs recorded in the SEEA Central Framework that are not recorded as part of ecosystem capital or ecosystem services. These are the inputs from mineral and energy resources, from excavated soil resources, and the inputs from renewable energy sources (excluding hydropower). In all of these cases the inputs are not considered to arise from interactions within ecosystems and hence, of themselves do not generate ecosystem services. This boundary is explained in more detail in Chapter 3. At the same time, it is recommended that information on these inputs should be presented alongside information on ecosystem services and ecosystem capital to provide a more complete set of information for policy and analytical purposes.

2.93 Second, the SEEA Experimental Ecosystem Accounts consider environmental assets from a different perspective compared to the SEEA Central Framework. Environmental assets, as defined in the Central Framework, have a very broad scope. Environmental assets are the naturally occurring living and non-living components of the Earth, together comprising the bio-physical environment, that may provide benefits to humanity (SEEA Central Framework, 2.17). This broad scope is intended to encompasses two perspectives. The first, which is the focus of the SEEA Central Framework is of environmental assets in terms of individual natural resources (e.g. timber, fish, minerals, land, etc). The second perspective, which is the focus of the SEEA Experimental Ecosystem Accounts, is of environmental assets as ecosystems in which the various bio-physical components are seen to operate together as a functional unit. Thus, conceptually, there is no extension of the bio-physical asset boundary in the SEEA Experimental Ecosystem Accounts.

2.94 Accounting for specific elements, such as carbon, or environmental features, such as biodiversity, are also covered in the SEEA Experimental Ecosystem Accounts but again these are specific perspectives taken within the same bio-physical environment as defined by environmental assets in the SEEA Central Framework.

2.95 While there is, in principle, no extension in the bio-physical environment, there are some particular boundary issues that need consideration, particularly concerning marine ecosystems and the atmosphere. The ocean and the atmosphere are excluded from the measurement scope in the SEEA Central Framework and their treatment in the context of ecosystem accounting requires further consideration.

2.96 More importantly, while the bio-physical starting point may be the same, the characteristics of environmental assets that are considered in ecosystem accounting are different from those considered in the SEEA Central Framework. This relates to the consideration of a wider range of individual and collective benefits (as noted above) that are generated from ecosystems. This expansion in the set of asset characteristics in scope of ecosystem accounting is the most significant extension and has implications for the way in which the measurement of assets in physical terms is undertaken (in particular it is essential to take into account any changes in the quality or condition of ecosystems) and the way in which valuation of ecosystems can be considered.

2.97 Third, the SEEA Central Framework outlines clearly the types of economic activity that are considered environmental and also describes a range of relevant standard economic transactions (such as taxes and subsidies) that are relevant for environmental accounting. It also shows how these flows may be organised in functional accounts – the main example being Environmental Protection Expenditure Accounts.

2.98 For the purposes of ecosystem accounts, there are no additional transactions that are theoretically in scope since the SEEA Central Framework has, in principle a scope that covers all economic activity related to the environment including protection and restoration of ecosystems. At the same time, the SEEA Experimental Ecosystem Accounts will include a discussion on the appropriate accounting treatment for emerging economic instruments related to the management of ecosystems, for example the development of markets for ecosystem services. There is no specific discussion on these types of arrangements in the SEEA Central Framework.