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DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS
STATISTICS DIVISION
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Seventh Meeting of the UN Committee of Experts on Environmental-Economic Accounting
Rio de Janeiro, 11-13 June 2012

SEEA Experimental Ecosystem Accounts

Chapter 1: Introduction

(for discussion)

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

SEEA Experimental Ecosystem Accounts

Draft material prepared for the 7th Meeting of the Committee of Experts on Environmental-Economic Accounting (UNCEEA)

Meeting in Rio di Janeiro, Brazil 11-13 June, 2012

DRAFT

Chapter 1: Introduction

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 1

The material for Chapter 1 is reasonably well advanced and, in general, only requires ongoing feedback to ensure the appropriate coverage of the various issues raised. A particular aspect in this regard is to obtain feedback from a wide range of stakeholders to ensure that the objectives and policy relevance of ecosystem accounts are clearly explained and provide a motivation to continue to read the other chapters.

A specific area requiring further feedback concerns the short section on principles of ecosystem science. It is planned to obtain direct input from ecologists on this issue both for Chapter 1 and for a related section in Chapter 2.

More broadly it is noted that the text in Chapter 1 will need to be revisited once various measurement concepts and definitions have been resolved in the other chapters to ensure an alignment of terminology and expression.

Chapter 1: Introduction

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Chapter 1: Introduction

1.1 What is the SEEA Experimental Ecosystem Accounts?

1.1 The System of Environmental-Economic Accounting (SEEA) Experimental Ecosystem Accounts is a companion to the SEEA Central Framework – the international statistical standard for environmental-economic accounting. The SEEA Central Framework is a multi-purpose, conceptual framework that describes interactions between the economy and the environment, and the stocks and changes in stocks of environmental assets. It provides a structure to compare and contrast source data and allows the development of aggregates, indicators and trends across a broad spectrum of environmental and economic issues.

1.2 The SEEA Experimental Ecosystem Accounts extends the accounting described in the Central Framework to consider the measurement of flows of services to society provided by ecosystems and the measurement of ecosystem capital in terms of the capacity, and changes in capacity, of ecosystems to provide those services.

1.3 Ecosystem accounting is a new and emerging field of measurement and hence this work is considered experimental. At the same time, ecosystem accounting builds on two well-established disciplines – the science of ecosystems, and national accounting and its application to environmental measurement. The merging of these disciplines represents a considerable challenge in terms of language, concepts and statistical practice. However, the potential for work on the most significant public policy challenges of this century to be assisted by coherent information as presented in ecosystem accounts requires that this challenge be confronted.

1.4 The SEEA Experimental Ecosystem Accounts describe both the measurement of ecosystems in physical terms, and the valuation of ecosystems in so far as it is consistent with the market based valuation principles of the System of National Accounts (SNA). More generally, only those topics for which broad consensus has emerged has been included. In accounting terms, the ecosystem accounts build on the accounting structures and conventions presented in the SEEA Central Framework and linkages between these two parts of the SEEA are explained through the text.

1.2 Objectives of ecosystem accounting

Policy relevance

1.5 There are a range of motivations for the development of ecosystem accounts. A general motivation is that ecosystem accounts provide a tool for tracking changes in the environment and linking that change to economic activity. A particular motivation for the development of the SEEA Experimental Ecosystem Accounts stems from the understanding that economic activity is leading to an overall degradation of the environment and, consequently, there is a reduced capacity for the environment to continue to provide the services and benefits that our society is dependent on. Therefore, it we are to stay within the bio-physical bounds of our environment we must consider ways in which economic activity can continue in a manner that has a reduced impact on the environment.

1.6 This motivation also provides the underpinnings for policy in the broad area of sustainable development, and also in policy areas such as resource efficiency and energy use, water supply and use, conservation and biodiversity, cleaner and more environmental friendly technologies, waste management, climate change, health and security (in terms of protection from natural hazards or resource supply).

1.7 The information organised in the SEEA Central Framework provides a basis for monitoring the interactions between the economy and the environment and for assessing the extent to which individual natural resources are being depleted. However, the information in the SEEA Central Framework cannot provide answers relating to the degree of impact of economic activity on the environment as a whole. The understanding that the environment operates as a system necessitates the development of information that takes this into account.

1.8 The SEEA Experimental Ecosystem Accounts start from this premise of seeing the environment as a system. At a national and sub-national level, these accounts aim to organise information about ecosystems –the dynamic complexes of biotic communities interacting with their non-living environment. It is from ecosystems that many environmental inputs flow into the economy and it is into these ecosystems that residuals flow from the economy. Ecosystem accounts thus represent a completing of the environmental-economic accounting picture.

1.9 With an understanding of the extent to which ecosystems are impacted by economic activity it is possible to evaluate the potential for alternative patterns of consumption and production, for alternative uses of energy and the extent of decoupling of growth, the effectiveness of resources spent to restore the environment, and the trade-offs between alternative uses of the environment.

1.10 Increasingly, policy in different areas of public concern are being considered in a more integrated, multi-disciplinary fashion with economic, social and environmental factors being assessed in determining appropriate policy responses. In this regard the integrated structure of the ecosystem accounts, and the SEEA generally, is of particular relevance. For ecosystem accounts the joint presentation of both economic data, and scientific and physical data is a particular feature.

1.11 The development of the SEEA at an international level provides a base to build information sets for use in assessing cross-border environmental impacts and global environmental challenges. At the same time the ecosystem accounting framework can be applied at a specific local level, for example in the management of river basins or protected areas.

1.12 The broad and integrated nature of the SEEA Experimental Ecosystem Accounts also makes it a relevant tool in the advancement of a number of international environmental frameworks including the Convention on Biodiversity and the UN Framework Convention on Climate Change (UNFCCC).

1.13 Overall, the policy relevance of the SEEA Experimental Ecosystem Accounts is very broad, real and increasing.

Accounting objectives

1.14 The particular focus in ecosystem accounting is on ecosystems and their relationship to the economy and society. Thus it represents a bringing together of ecosystems, economic and statistical perspectives on this relationship.

1.15 The over-arching objective of developing an accounting structure is the integration of environmental and economic information to inform policy discussion and environmental management. Within this, the more specific objectives in establishing an accounting structure are:

- Organising information on ecosystems in a coherent manner by developing conceptual linkages between ecosystems, economics and statistics
- Consistent application of a common set of concepts and terminology
- Allowing connections to be made to environmental/economic information compiled following the SEEA Central Framework
- Permitting integration with the standard national accounts (as described in the SNA) to aid the measurement of the production and consumption of ecosystem services, the attribution of the degradation of ecosystems to economic units, the recording of expenditure by economic units on the maintenance and restoration of ecosystem, and the development of wealth accounting.
- Identifying information gaps and key information requirements

1.16 In order to meet the various accounting objectives, there are some specific considerations that are the focus of the SEEA Experimental Ecosystem Accounts. These are:

- the objects of measurement – the ecosystems – need to be defined from a statistical perspective;
- the definition of, and relationships between, the relevant stocks and flows with consideration of appropriate measurement scope and coverage;
- common measurement units for the assessment of ecosystem capital need to be described;
- the structure of relevant accounts needs to be outlined including links to the core economic accounts of the SNA and accounts described in the SEEA Central Framework; and

- the use of valuation techniques needs to be explained

1.17 Central to the success in meeting these various accounting objectives is the involvement of a wide-range of professional communities, most notably scientists, economists and official statisticians. While all three of these communities come from differing perspectives, each group has an important role to play in developing the appropriate accounting framework and in populating that framework with meaningful information.

1.18 It is highly unlikely that any single agency or organisation can effectively cover all of the information requirements for a set of ecosystem accounts. This is particularly the case for the range of scientific and other environmental information which may be very localised. Consequently, the development and testing of ecosystem accounting will require the involvement of multiple disciplines across agencies and the establishment of appropriate institutional frameworks is likely to be important if the work is to be routinely implemented.

1.19 Given its new and emerging status there is strong potential to harness the research capability of the academic sector to develop and test aspects of the ecosystem accounting framework that is proposed. This engagement, in addition to the involvement of relevant government agencies, will provide a firm foundation for the development of ecosystem accounts.

The experimental nature of SEEA Experimental Ecosystem Accounts

1.20 The SEEA Experimental Ecosystem Accounts have been labelled “experimental” because they represent a summary of the state of play of an emerging area of research. The emerging area of research is in the combination of principles from ecosystem science, economics, national accounts and official statistics. Strong progress has been made in combining these various streams which has permitted the writing of these chapters. While a broad consensus exists on the purpose and general framework for measurement, there remain a number of areas in which further investigation of alternative approaches to measurement is required.

1.21 It is emphasised that the experimental label should not be applied to any of the individual disciplines that are being brought together in the context of ecosystem accounting. All of the disciplines noted have long-standing concepts, frameworks and perspectives on the world in which we live. It is the integration of these well-established concepts within the discipline of accounting that is the new element being considered here. Of course, each area will continue to advance and develop and resolve outstanding issues and, in the fullness of time, these refinements and advances will play a role in advancing ecosystem accounting.

1.22 In this context, the SEEA Experimental Ecosystem Accounts is conservative in nature, and does not seek to incorporate the leading edge (or all) aspects of each discipline. Rather it restricts itself to offering direction based on broadly accepted consensus within each of the disciplines. Nonetheless, by presenting each of the disciplines in an integrated fashion, the approach clearly opens up new avenues for investigation and experimentation.

1.23 A full articulation of ecosystem accounts will, inevitably, require the use of a significant amount of data. However, although this is a new area of accounting, it is the case that a large amount of information for populating ecosystem accounts can be accessed from existing data sources. Inevitably, some of the data may be proxies of the “ideal” measures but this, in itself does not invalidate the accounting framework or the potential to use carefully organised and structured information. In general, the population of the basic datasets for ecosystem accounting can be done using common scientific and statistical methods, although, there may be a need for some experimentation in the development of data at finer levels of spatial detail (i.e. for small areas). In this regard, there is a significant opportunity to take advantage of emerging spatially specific datasets and related analytical techniques.

1.3 The relationship of ecosystem accounts to ecosystem science and national accounts

1.24 While ecosystem accounting is a new and emerging field of measurement its foundation in both ecosystem science and national accounts is strong. Research in both of these foundation areas continues to deal with the ever increasingly complexity of economic activity and our ever increasing understanding of the world in which we live. At the same time there are some core understandings of ecology and national accounts that are accepted and hence form a base for ecosystem accounting.

Core principles of ecosystem science

1.25 An ecosystem can be broadly defined as a community of organisms, together with their physical environment, viewed as a system of interacting and interdependent relationships and including such processes as the flow of energy through the food chain and the cycling of carbon, water and nutrients through living and non-living components of the system.

1.26 Key processes in ecosystems include the capture of light, energy and carbon through photosynthesis, the transfer of carbon and energy through food webs, and the release of nutrients and carbon through decomposition. Biodiversity affects ecosystem functioning, as do the processes of disturbance and succession. The principles of ecosystem management suggest that rather than managing individual species, natural resources should be managed at the level of the ecosystem itself.

1.27 Ecosystems provide a variety of goods and services upon which people depend, known as ecosystem services. The capacity of the ecosystem to provide ecosystem services depends on the area covered by an ecosystem (its extent), and the condition of the ecosystem. This capacity is modified through human behaviour. Through land use conversion, ecosystems have been replaced by different ecosystems supplying a different set of ecosystem services, as in the case of forest converted to cropland. The supply of ecosystem services is also influenced by the changing condition of an ecosystem, which in turn is a function of ecosystem structure, components and processes.

1.28 Ecosystems are often subject to complex, non-linear dynamics involving negative or positive feedback loops. These complex dynamics include, for example, the presence of multiple steady states, irreversible change or stochastic (random) behaviour. It is now recognised that many types of ecosystems are influenced, and often dominated by complex dynamics, including temperate and tropical forests, rangelands, estuaries, and coral reefs. Resilience is an important property of ecosystems in this regard. Resilience indicates the propensity of ecosystems to withstand pressure or to revert back to its original condition following a disturbance.

1.29 The relationship between biodiversity and ecosystem functioning and resilience is still debated. While a range of theories has been formulated, the dominant view at present implies that genetic and species diversity within functional groups is an essential element of ecosystem resilience. Thus, in case one of the species in a functional group is strongly reduced in number, for example because of a pest or disease, species diversity within this functional group increases the chance that other species can substitute its role in ecosystem functioning.

Core principles of national accounts

1.30 At the heart of national accounting is the ambition to record, at a national, economy-wide level, measures of economic activity and associated stocks and changes in stocks of economic assets. The accounting approaches are described at length in the System of National Accounts (SNA). The SNA is the international statistical standard for national accounting, first released in 1953 and most recently updated in 2008 and released jointly by the United Nations, the European Commission, the International Monetary Fund, the Organisation for Economic Co-operation and Development (OECD) and the World Bank. In turn, the SNA provides the conceptual underpinnings of the new international standard, the SEEA Central Framework.

1.31 Following the SNA, economic activity is defined by the activities of production, consumption and accumulation. Measurement of each of these activities over an accounting period (commonly one year) is undertaken within the constraint of a production boundary which defines the scope of the goods and services considered to be produced and consumed.[1] Accumulation of these goods and services in the form of economic assets (for example, through the construction of a house) is recorded in cases where production and consumption is spread out over more than one accounting period. Further, non-produced economic assets may be accumulated (for example, through the purchase of land). At its core, national accounts is the reporting of flows relating to production, consumption and accumulation, and stocks of economic assets.

1.32 Central to the measurement of economic activity and economic assets is the recognition of economic units – i.e. the different legal and social entities that participate in economic activity. At the broadest level these entities are categorised as enterprises, governments and households. The economy of a given territory is defined by the set of economic units (referred to in the SNA as institutional units) that are resident in that territory.

1.33 The national accounts thus aim to organise and present information on the transactions and other flows between these economic units (including flows between units in different territories), and on the stocks of economic assets owned and used by economic units.

1.34 There are strong similarities between national accounting and the accounting that is undertaken for an individual business. However, the main distinctions are that (i) national accounting requires consideration of the accounting implications for more than one business (thus the recording must be consistent for both parties to a transaction without overlaps or gaps); and (ii) national accounting operates at a far larger scale in providing information for a

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[1] This boundary also defines the measurement scope for the most widely known national accounts aggregate, Gross Domestic Product (GDP).

country and encompassing a wide variety of types of economic units that play quite distinct roles in an economy.

Creating linkages between ecosystem science and national accounting

1.35 Placing ecosystems in a national accounting context requires both disciplines to consider measurement in new ways. For ecologists, this requires creating clear distinctions between stocks and flows within an ecosystem and to differentiate between those aspects of ecosystems that provide direct benefits to society and those aspects of ecosystems that, effectively, support the provision of these benefits.

1.36 For national accounts, it is necessary to consider the set of goods and services produced and consumed in the context of the set of benefits provided by ecosystems and also to see the ecosystem as a complex, self-regulating system that, while influenced by economic activity, also operates outside of traditional economic management regimes.

1.37 Fundamentally, both ecosystem science and national accounting are disciplines that recognise the significance of systems and the mass of relationships that comprise their fields of interest. Ultimately, it is the aim of the SEEA Experimental Ecosystem Accounts to take advantage of this common approach and present a system based approach to recording the relationships between society and ecosystems that is useful for public policy making and environmental management.

1.4 Relationship between the SEEA Experimental Ecosystem Accounts and the SNA and the broader SEEA

1.38 The SEEA Experimental Ecosystem Accounts are a companion to the SEEA Central Framework – the international statistical standard for environmental-economic accounting. These two parts of the SEEA are complemented by a third part titled SEEA Extensions and applications. This third part presents a range of monitoring and analytical approaches that could be adopted using information that has been brought together within the SEEA accounting frameworks and describes ways in which SEEA can be used to inform policy analysis.

1.39 As an accounting framework for use in public policy, the SEEA Experimental Ecosystem Accounts has strong connections to the System of National Accounts (SNA). It is the SNA that provides the basic accounting rules and principles, and the underlying systematic approach to the recording of stocks and flows at a national level.

1.40 This section describes the links between the SEEA Experimental Ecosystem Accounts and the SNA and its links to the SEEA Central Framework.

Relationship between ecosystem accounts and the SNA

1.41 As for the SEEA Central Framework, the SEEA Experimental Ecosystem Accounts uses the SNA as the source of accounting rules and principles. As well, the SNA provides the underlying systematic approach to measuring stocks and flows at a national level and it is this systematic approach that is applied in the ecosystem accounts.

1.42 While some core elements of the SNA are retained in the ecosystem accounts there are some particular accounting treatments in defining measurement boundaries that are applied in the SEEA Experimental Ecosystem Accounts that are different from the SNA. The following are of most relevance.

1.43 First, the SEEA Experimental Ecosystem Accounts encompass measures in both physical and monetary terms whereas the SNA covers only estimates in monetary terms. This extension in coverage is a significant one from the perspective of interpreting and integrating environmental information and aligns with the direction set out in the SEEA Central Framework. As with the SEEA Central Framework the aim in ecosystem accounting is to present physical information following a structure that is compatible with the structures used for presenting economic data in monetary terms.

1.44 Second, regarding valuation, -- to be completed once discussion on Chapter 5 is complete --.

1.45 Third, the asset boundary applied in the SEEA Experimental Ecosystem Accounts is broader that that used in the SNA. In the SNA the asset boundary with respect to environmental assets is limited to those assets that have economic value in the sense that they have an expected stream of benefits (in the form of income) to be received in the future. This boundary is defined in monetary terms but implicitly applies in physical terms. Thus physical features of the landscape without economic value are excluded from the SNA.

1.46 In the ecosystem accounts this asset boundary is extended in two respects. First, as in the SEEA Central Framework, the coverage of environmental assets in physical terms is extended to encompass all naturally occurring living and non-living components of the Earth although it is a sub-set of this that is incorporated into ecosystem accounts (for example mineral and energy resources are not considered part of ecosystems). Second, a broader set of benefits from ecosystems are recognised in the SEEA Experimental Ecosystem Accounts thus expanding the concept of value relative to the SNA.

1.47 Fourth, related to the recognition of a broader set of benefits from ecosystems, the SEEA Experimental Ecosystem Accounts applies a modified production boundary such that the full range of flows from ecosystems that benefit society can be accounted for. Examples include the provision of clean air and flood protection via the existence of well-functioning ecosystems.

1.48 Although there are some differences in the scope of ecosystem accounts relative to the SNA, the extensions are applied in a manner which permits the integration of ecosystem accounts with the SNA accounts. This feature is important in the development of integrated measures of economic activity that take into account the consumption of ecosystem capital and the compilation of wealth accounts that contrast ecosystem capital with other assets such as produced assets and financial assets that are recorded in the SNA.

Relationship between ecosystem accounts and the SEEA Central Framework

1.49 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.

1.50 First, the SEEA Experimental Ecosystem Accounts extend the range of physical flows that are accounted for to include non-material benefits that are obtained from the environment. 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). The SEEA Experimental Ecosystem Accounts add to this by including the measurement of the non-material benefits that emerge from ongoing ecosystem processes (such as the regulation of climate, air filtration and flood protection) and the non-material benefits from human engagement with the environment (such as recreation activity).

1.51 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 encompasses both a view of environmental assets in terms of individual resources (e.g. timber, fish, minerals, land, soil, water) and a view of environmental assets as ecosystems in which the various bio-physical components are seen to operate together as a functional unit. Thus, in principle there is no further extension of the bio-physical asset boundary in the SEEA Experimental Ecosystem Accounts.

1.52 However, 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 incorporation of non-material benefits that are generated from ecosystems (as noted above). 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 is considered.

1.53 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.

1.54 While there is, in principle, no extension in the bio-physical environment that is in scope, there are some particular boundary issues that needs 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.

1.55 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. In also shows how these flows may be organised in functional accounts – the main example being Environmental Protection Expenditure Accounts.

1.56 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 instrument 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.

1.5 Structure of the SEEA Experimental Ecosystem Accounts

1.57 Chapter 2 "Principles of ecosystem accounting" presents the model of ecosystem operation that underpins the accounting framework and places into context ecosystems, ecosystem services, ecosystem capital and consumption of ecosystem capital. These various elements are subsequently described in greater detail in later chapters. Chapter 2 also discusses the definition of statistical units for ecosystems that become the focus for measurement and accounting, and outlines some general measurement issues that apply to all areas of ecosystem accounting.

1.58 Chapter 3 "Accounting for ecosystem services in physical terms" discusses the measurement of ecosystem services highlighting key issues of scope and coverage, presenting a common classification of ecosystem services, proposing basic accounting structures for recording flows of ecosystem services, and describing a range of examples of the measurement of ecosystem services in physical terms.

1.59 Chapter 4 "Accounting for ecosystem capital in physical terms" considers measures of ecosystem capital in physical terms comprising measures of ecosystem extent, condition and capacity. It explains approaches to measuring ecosystem capital, the organisation of this information into ecosystem capital accounts, and the measurement challenges involved in making overall assessments of ecosystems. Chapter 4 also highlights some specific areas of accounting, namely carbon accounting and accounting for landscape and species biodiversity, and the relationship of these specific areas to ecosystem accounting.

1.60 Chapter 5 "Approaches to valuation for ecosystem accounting" introduces the principles of valuation that are applied in the SEEA and outlines a range of ways in which valuation of ecosystem services and ecosystem capital might be undertaken and the relevant measurement issues. The chapter also considers the organisation of information estimated in monetary terms and issues of aggregation and scaling estimates for individual ecosystem services and individual ecosystems.

1.61 Chapter 6 "Accounting for ecosystems in monetary terms" shows how estimates of ecosystem services and ecosystem capital in monetary terms can be integrated with information in the core national accounts, including via a sequence of accounts and via wealth accounts. This chapter also highlights the way in which standard monetary transactions associated with ecosystems can be recognised and recorded.

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SEEA Experimental Ecosystem Accounts

Chapter 2: Principles of ecosystem accounting

(for discussion)

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Chapter 2: Principles of ecosystem accounting

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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

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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.

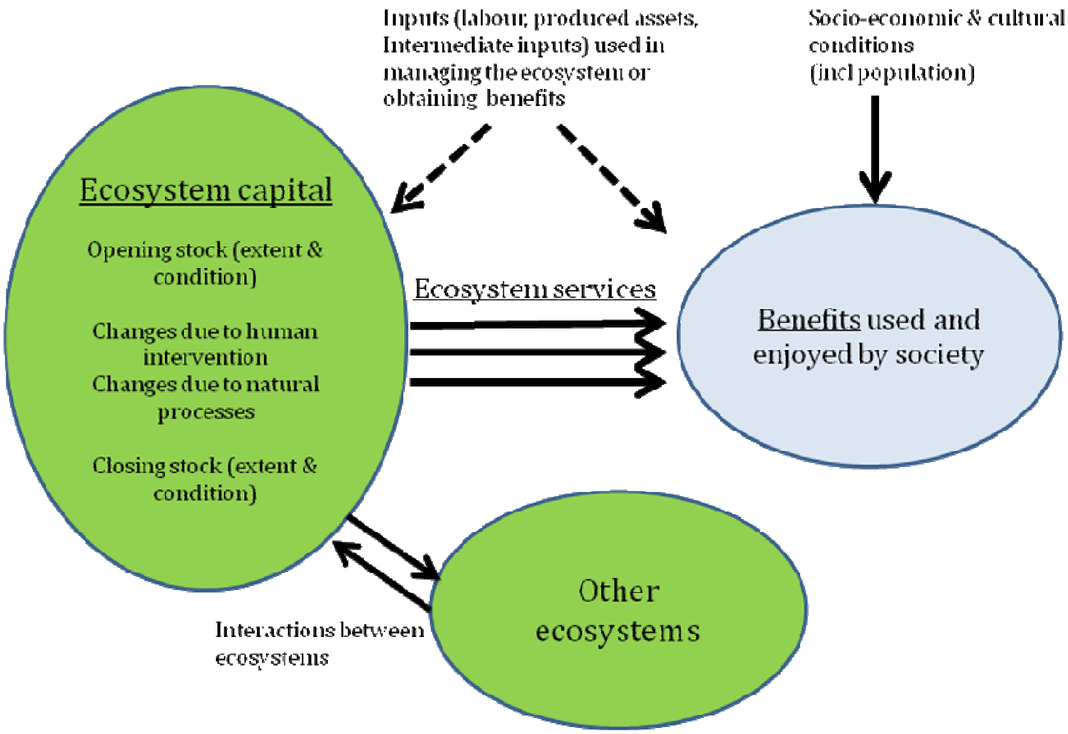
2.12 A range of definitions for ecosystem services have developed and used in various contexts from site specific case studies to large national and global assessments of ecosystems. Often the basic concept of ecosystems supplying resources and processes that are of use to society can be lost in different 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.

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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.

[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.

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DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS
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Rio de Janeiro, 11-13 June 2012

SEEA Experimental Ecosystem Accounts

Chapter 3: Accounting for ecosystem services in physical terms

(for discussion)

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

SEEA Experimental Ecosystem Accounts

Draft material prepared for the 7th Meeting of the Committee of Experts on Environmental-Economic Accounting (UNCEEA)

Meeting in Rio di Janeiro, Brazil 11-13 June, 2012

DRAFT

Chapter 3: Accounting for ecosystem services in physical terms

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 3

The material around the definition of ecosystem services and the examples of ecosystem services has developed well and provides a sound base for the measurement of ecosystem services in physical terms. At the same time further work is required in two specific areas.

First, a draft of the Common International Classification of Ecosystem Services (CICES) is needed to support work in this area. As part of drafting CICES clarification is needed on the treatment of abiotic resources (such as mineral and energy resources) and on the appropriate time and point of recording of ecosystem services for cultivated resources such as livestock and crops. A process to finalise a draft CICES has commenced as a first round of feedback has been completed. Finalisation of this work will also be used to confirm the set of examples of ecosystem services included in Section 3.4.

Second, proposals for accounting tables need to be finalised. These proposals rely on developments in CICES and on the discussion on statistical units discussed in Chapter 2. Also, some further discussion is needed among those more closely involved in ecosystem accounting as to the type of information that should be included in ecosystem services related tables.

Chapter 3: Accounting for ecosystem services in physical terms

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Chapter 3: Accounting for ecosystem services in physical terms

3.1 General concepts and principles in measuring ecosystem services

3.1 Ecosystem services have become a central concept in connecting biophysical information on ecosystem processes and ecosystem capital with the benefits received from ecosystems by society. As described in the core ecosystem accounting model in Chapter 2, ***ecosystem services are the contributions of ecosystems to benefits used or enjoyed by society.***

3.2 The measurement of ecosystem services needs to consider a range of factors to appropriately define the object of measurement. First, there may often be a series of ecosystem processes that take place within ecosystems before the ecosystem services are captured and benefits arise. For instance, forest patches support bee populations which in turn pollinate fruit trees which are, in the final step, harvested. Recording the flows associated with each step would overstate the total flow of ecosystem services as contributions to society. Further, it is often very difficult to disentangle the specific contribution of different steps.

3.3 Recognising these multiple interactions, the SEEA, in order to record only the contribution of ecosystems to benefits used or enjoyed by society, adopts a measurement scope of ecosystem services that only includes what might be termed the 'final ecological output' from ecosystems. As explained in Chapter 2, these final ecosystem services may be used by households, enterprises or government to produce goods and services. Consequently, the internal flows of ecosystem processes, often referred to as intermediate or supporting services, are excluded from the measurement scope of ecosystem services.

3.4 Second, it is considered that ecosystem services are generated as a result of bio-physical, geo-chemical, and other physical processes and interactions within an ecosystem. Consequently, flows from the environment such as extractions of mineral and energy resources and the capture of energy from renewable sources, such as wind and solar energy, are not considered ecosystem services in the SEEA.[1]

3.5 Third, the distinction between ecosystem services and the benefits to which they contribute is an important one that recognises that, in many situations, the contribution of the ecosystem is just one of the inputs required in order for society to receive the benefits from an ecosystem. Often, though not always, the service provided by an ecosystem is combined with inputs of labour, produced assets and intermediate consumption (e.g. fuel) in order to generate a benefit. For example, a tree must be cut down using labour and a chainsaw before the benefit of using it for timber can be realised. These benefits are considered material benefits which, by definition, arise from a production process as defined in the SNA.

3.6 At the same time, there are also important benefits which are received without the use of any production processes – for example the benefit of clean air that arises from the air filtration

[1] At the same time it is recommended that data on these flows be compiled in conjunction with ecosystem accounts.

services from trees. In these cases the ecosystem services and the benefits are considered equivalent. These benefits are defined as non-material benefits.

3.7 There are also a broader range of conditions and factors that must be considered in the measurement of ecosystem services. Since ecosystem services are measured only when benefits can be identified, the conditions and factors that influence the receipt of benefits are relevant. For example, the receipt of benefits from the air filtration processes of trees is dependent upon the number of people in sufficiently close proximity to the relevant patch of trees. The consideration of these conditions and factors is particularly important in the measurement of ecosystem services that result in non-material benefits.

3.8 Following standard practice in economic accounting, the flow of ecosystem services into economic activity is necessarily an intermediate flow into the generation of material benefits. Then, depending on how the material benefit is used, it may be recorded as part of intermediate consumption (e.g. the use of wood in the manufacture of furniture) or as part of final consumption (e.g. the collection of wood by households for heating, benefits of recreation from visiting a forest).

3.9 Material benefits that are generated using, in part, contributions from ecosystem services are already in scope of the production boundary of standard measures of economic activity as defined in the SNA and as used in the SEEA Central Framework. Examples include the benefits from the commercial supply of wood, crops etc. This boundary also includes the products produced by subsistence agriculture and fishing, and all own-account activity of household (such as the collection of fuelwood, water and forest products for own-use).

3.10 However, non-material benefits are not within scope of the standard production boundary and the recognition of these benefits and the associated ecosystem services is an important part of ecosystem accounting. Often non-material benefits are characterised as being in the form of avoided costs e.g. the benefits of air filtration arise in the form of reduced health care costs and improved quality of life. However, in the SEEA, this characterisation is considered a link to outcomes rather than outputs and is not the focus of the accounting model. Rather non-material benefits are described in a manner analogous to goods and services produced in the economy – e.g. clean air from air filtration services.

3.11 From a societal perspective there may often be outcomes from ecosystem processes that are seen as negatives (e.g. pests and diseases). These ecosystem disservices often originate from a combination of ecological processes and adverse human management. In part, these disservices are included in the ecosystem accounts in an indirect manner, for example when agricultural pests lead to declines in ecosystem capital and a reduced supply of ecosystem services. However, other disservices that directly enter the production or consumption functions of households, enterprises and governments (e.g. natural pathogens having an impact on health) are not accounted for. The relationship between these disservices and benefits as defined in the SEEA may be difficult to establish and, in addition, for many of these effects, there is only a weak correlation between consumption of ecosystem capital and the management of the disservice.

3.12 It is recognised that the vast majority of the world's ecosystems have been modified by people, often with the purpose of enhancing the production of one or more specific ecosystem services, and often having offsetting effects on the availability of non-material benefits. These modifications by people (which include efforts to restore ecosystems) impact on the capacity of ecosystems to provide ecosystem services and are accounted for as part of assessments of ecosystem capital described in Chapter 4.

3.13 The ecosystem accounting relationships described in Chapter 2 also consider the returns to the ecosystem. For instance, when trees are felled, there are logging residues that remain in the ecosystem. In addition, economic activity may lead to pollution or other pressures on the ecosystem, or on nearby ecosystems. These pressures are highly relevant for ecosystem management, but are site and case-specific and not further described in this section. They are however, included in the SEEA to the degree that they lead to consumption of ecosystem capital, i.e. a decrease in the capacity of ecosystems to supply ecosystem services.

3.2 Scope and classification of ecosystem services

3.14 At the broadest level three different categories of ecosystem services are distinguished in the SEEA: (i) provisioning services; (ii) regulating services; and (iii) cultural services.

3.15 *Provisioning services* reflect contributions to the goods and services produced by or in the ecosystem, for example a piece of fruit or a plant with pharmaceutical properties. These goods and services may be provided by agricultural systems (arable land, permanent crops, pastures), as well as by semi-natural and natural ecosystems.

3.16 *Regulating services* result from the capacity of ecosystems to regulate climate, hydrological and bio-chemical cycles, earth surface processes, and a variety of biological processes. These services often have an important spatial aspect. For instance, the flood control service of an upper watershed forest is only relevant in the flood zone downstream of the forest. The nursery service can also be classified as a regulation service. It reflects that some ecosystems provide a particularly suitable location for reproduction and involves a regulating impact of an ecosystem on the populations of other ecosystems.

3.17 *Cultural services* relate to the intellectual and symbolic benefits that people obtain from ecosystems through recreation, knowledge development, relaxation, and spiritual reflection. This may involve actual visits to an area, indirectly enjoying the ecosystem (e.g. through nature movies), or gaining satisfaction from the knowledge that an ecosystem containing important biodiversity or cultural monuments will be preserved. The latter may occur without having the intention of ever visiting the area. The category cultural services also includes the biodiversity conservation service that represents the benefits that people obtain from the existence of biodiversity and nature and the passing of it on to subsequent generations (not because biodiversity provides a number of services, but because people believe its conservation is important in itself).

3.18 These three types of ecosystem service form the highest level of the *Common International Classification of Ecosystem Services* (CICES). The next levels in the hierarchy are shown in Table 3.1. The annex to SEEA Experimental Ecosystem Accounts contains some additional detail showing examples of services that might be included in the different classes. Experience to date suggests that at a broad level the structure of CICES can be used in a range of situations. However, the CICES presented in the SEEA is provisional and it is anticipated that it will be refined over time as ecosystem accounting develops further.

Table 3. 1 Higher levels of CICES

(To be finalised)

3.19 There are two significant boundary issues in relation to CICES. The first relates to the so-called intermediate or supporting services. These flows relate to all of the underpinning ecosystem processes within an ecosystem that reflect the ongoing operation of ecosystems including things such as soil formation, nutrient cycling, etc. There is little doubt that these flows are central to the operation of ecosystems. However, in the ecosystem accounting model they are not considered contributions to benefits received by society – i.e. they are not final ecological output. In an accounting sense they are embodied in the provisioning, regulating and cultural services which they underpin. While they are not considered ecosystem services, these flows are an important part of accounting for ecosystem capital, in particular for the changes in ecosystem capital over an accounting period.

3.20 The second issue concerns flows related to abiotic materials. Society takes significant advantage of abiotic materials found in the environment (such as underground mineral and energy resources) and also captures many abiotic flows for various purposes (particularly the capture of energy from solar and wind sources). However, since these materials and flows do not arise as a result of interactions within ecosystems and because the availability of these materials and flows cannot be managed on human time scales, they are not considered ecosystem services.

3.21 At the same time it is recognised that the assessment of ecosystems necessarily requires consideration of these flows. Ecosystem capital is likely to be impacted by decisions to capture and extract these materials and flows, and the residuals that result from the use these materials also impacts on ecosystems. Therefore, although these flows are not included as part of ecosystem services, these flows are grouped in a fourth section of CICES titled "Other environmental flows". It is recommended that relevant information relating to these flows be compiled in the context of ecosystem accounting to permit assessment of tradeoffs between alternative uses of land and ecosystems. The measurement of these flows is discussed in some detail in the SEEA Central Framework Chapters 3 and 5.

3.22 In the same way as internal flows of an ecosystem are excluded from the measurement scope of ecosystem services, flows between ecosystems are also excluded, including flows between ecosystems in other countries. At the same time imports and exports of ecosystem services may arise, for example, when visitors to a country enjoy a walk in a forest, the associated ecosystem service is a contribution to a produced benefit that is recorded as an export.

3.23 Section 3.4 describes a range of approaches that might be considered in the measurement of ecosystem services in physical terms.

3.3 Accounting structures for ecosystem services

3.24 The aim of ecosystem service flow accounts is to organise information on the flows of ecosystem services by type of service, by statistical unit, and by economic units considered responsible for utilising the service. In addition it will be relevant to identify the recipients of both material and non-material benefits that arise from using the contributions of ecosystem services.

Tables proposed for inclusion but yet to be finalised:

Table 3.2 Ecosystem service flows by ecosystem accounting unit (EAU)

Table 3.3 Ecosystem service flows by ecosystem accounting unit and responsible economic unit

Table 3.4 Ecosystem service flows by ecosystem accounting unit and benefit recipient

3.4 Measurement approaches for selected ecosystem services

3.25 The following section describes potential approaches to the measurement of a range of ecosystem services in physical terms in order to assist compilers in commencing work on the measurement of ecosystem services and to better explain the measurement concepts. It is not possible to identify and define all ecosystem services and hence the intent here is to highlight relevant issues in the measurement of the most commonly recognised ecosystem services. Section 3.5 discusses considerations that might be taken into account in determining the set of ecosystem services that should be measured.

3.26 The approach taken to describe the measurement approaches is to describe individual ecosystem services. It is recognised that presenting the information in this de-constructed way may give the impression that ecosystem services are easily separable flows. In reality, the measurement of ecosystem services must start from a more holistic sense of an overall ecosystem and the range of different services that effectively emerge from the ecosystem as a bundle of services. However, as a matter of statistical and scientific approach, direct measurement of this bundle is not possible and hence a decomposition must be adopted.

3.27 Table 3.5 presents the list of ecosystem services that are described in more detail in this section. The table includes a brief description and some potential indicators.

Table 3.5 List of selected ecosystem services described in Section 3.4

Name of ecosystem service	**Description of ecosystem service**	**Corresponding benefit**
Provisioning Services		
Crops	Crops from intensive and extensive agriculture including shifting cultivation	Crops can be consumed directly or further processed.
Fodder for livestock	Rangelands provide fodder (grass, herbs, leaves from trees) for livestock	Livestock products (including animals, meat, leather, milk)
Raw materials including wood and non-timber forest products	Ecosystems, in particular forests, generate stocks of wood and non-timber forest products that may be harvested. Non-timber forest products include for instance rattan, various food products, genetic materials, ornamentals, and pharmaceutics.	Firewood, logged timber, non-timber forest products.
Fish and other aquatic and marine species from marine and inland waters	Marine and other aquatic ecosystems provide stocks of fish and other species that can be harvested.	Fish and other species can be consumed or further processed.
Fish from aquaculture	Aquaculture systems are used to cultivate a variety of fish and other aquatic and marine species.	Fish and other species can be consumed or further processed.
Water	Ecosystems filter and store water that can be used as raw material for drinking water production	Drinking water
Regulating Services		
Carbon sequestration	Ecosystem sequester and store carbon	Climate regulation
Air filtration	Trees can filter particulate matter from ambient air	Cleaner air
Flood protection	Ecosystems regulate river flows and can provide a barrier to floods	Protection of properties and lives
Cultural services		
Providing opportunities for tourism and recreation	Ecosystems present physical space and landscape features people enjoy, to watch or undertake activities in (hiking, cycling)	Recreational benefits

3.4.1 Provisioning Services

3.28 Provisioning services should be the most amenable to measurement as they are within the production boundary of the SNA and the SEEA Central Framework and hence flows of these services can be directly related to relevant measures of production (e.g. cubic metres of timber, tonnes of fish, etc).

3.29 The scope of provisioning services covers outputs from both cultivated and natural biological resources. Cultivated and natural biological resources are distinguished in the SNA and in the SEEA Central Framework to recognise that the growth of biological resources is managed to a greater extent in some cases compared to others. Thus, for example, the rearing of livestock and fish, the growing of crops, and the farming of orchards, vineyards and plantations, are all considered to result in the production of cultivated biological resources. Conversely, the harvesting of fish on the high seas, the felling of timber in naturally regenerated forests, and the hunting of wild animals are all considered to be the extraction of natural biological resources.

3.30 The distinction between cultivated and natural biological resources impacts on the accounting in the SNA by altering the time at which the production of the resources is recorded. For natural biological resources the production is recorded at the point of extraction or harvest, whereas for cultivated biological resources the production is recorded on an ongoing basis as the resources grow.

3.31 More significantly, there are also large differences in the production functions of the different resources with many more inputs being recorded in the case of cultivated biological resources. But this is a difference in terms of extent rather than a difference in conceptual treatment of the production activity.

3.32 From the perspective of ecosystem services it is the case that, whether the biological resource is cultivated or natural, the broad set of relevant ecosystem processes will be the same. Put differently, nature makes no distinction in terms of its contribution to growing a tree in a plantation as distinct from a naturally regenerated forest. However, the point in the production process at which the contribution of the ecosystem is recognised will vary depending on the degree of cultivation that is undertaken. Thus, the final ecosystem service in a case of completely natural growth will be the tree or animal that is harvested. Conversely, in a heavily cultivated situation, the final ecosystem service will relate to the grass that is eaten by livestock or the nutrient uptake by plants.

3.33 Unfortunately, there are no neat boundaries around degrees of cultivation and there is a limited ability to distinguish between varying production process to determine the extent to which different ecosystem processes are final. Thus various conventions are adopted to enable ecosystem accounting to be completed. It is recognised that at the scales at which ecosystem accounting for the SEEA is undertaken (i.e. at regional and national levels) these conventions are unlikely to have a significant impact on the overall measures. However, for more detailed studies in specific sites a more fulsome articulation of ecosystem service flows linking final and intermediate services may be useful.

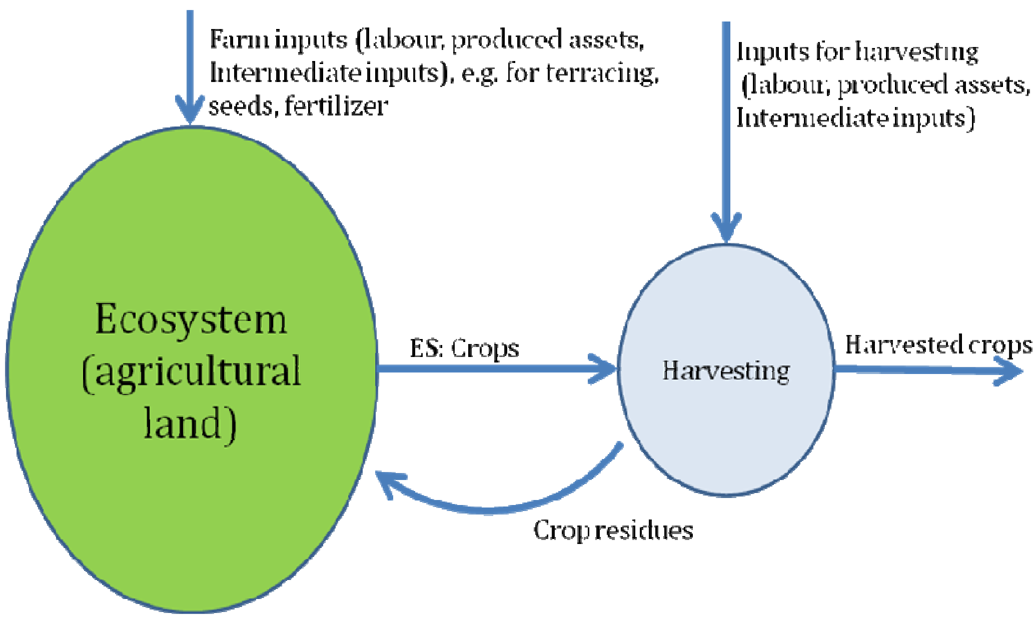
3.34 In the following paragraphs, common ecosystem services are elaborated on the basis of a short description and an illustration. The figures present the ecosystem, the flow of ecosystem services (i.e. the goods that are extracted from the ecosystem), the activity required to extract the ecosystem service, and examples of the subsequent benefits. In reality, an ecosystem service may generate a cascade of different benefits (e.g. timber may be converted into a table) and only one or a few illustrative benefits are shown in the figures.

3.35 The figures below also depict the inputs of labour and produced assets required to (i) mange the ecosystem,; and (ii) harvest or extract the ecosystem service. The distinction between these two types of inputs is made for the following reason. For any provisioning service, there are always costs related to extracting the service, be it harvesting a crop, felling timber, or catching fish. These costs are paid at a specific point in time and they may rise when stocks become depleted or ecosystems degrade. However, the costs for managing the ecosystem vary substantially between different ecosystems and vary with the degree of human modification of the ecosystem. These costs may be made on an ongoing basis in order to maintain the productive capacity of the ecosystem.

Provisioning of crops

3.36 Agricultural production includes the production of annual and perennial crops in cultivated land including plantations, see Figure 3.1. The ecosystem service comprises the harvest of crops and other products from the ecosystem. The farmer or land manager is (i) managing the overall production environment, i.e. the farm or plantation, for instance by constructing a wind break or an irrigation reservoir; and (ii) harvesting crops using labour and machinery. In practice, it may not always be easy to distinguish between these different inputs at an individual farm level. Crop residues are recorded as remaining in the field, and returned to the ecosystem.

Figure 3.1. **Agricultural production**

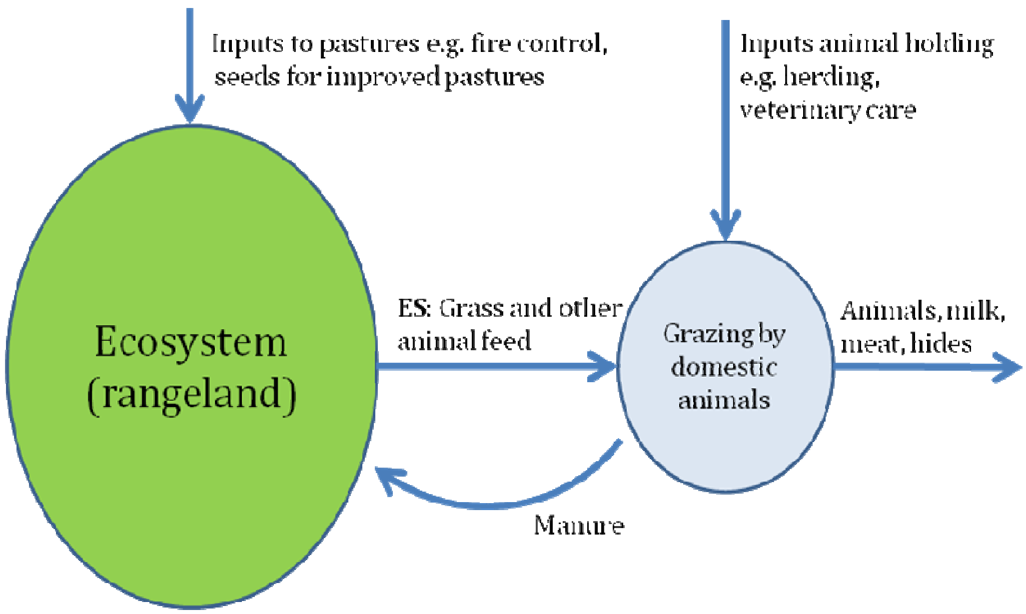


Provisioning of fodder for livestock

3.37 In livestock grazing, the service supplied by the ecosystem relates to the amount of animal fodder produced in the ecosystem, as it is grazed by livestock. This animal fodder comprises annual and perennial grasses and herbs, leaves from trees, etc. The livestock holding system may be more or less intensive, for instance free ranging cattle grazing large stretches of semi-arid rangeland, or dairy cattle grazing confined pastures. The land manager may invest in managing the overall ecosystem, for instance by sowing improved pasture varieties, or by building fences or firebreaks. Livestock holding is the activity undertaken by the land manager in the ecosystem, involving all aspects related to animal production and resulting in outputs of animals, wool, milk, meat, hides, etc.

3.38 The ecosystem service can be measured in physical terms in terms of amount of fodder grazed by animals on an annual basis. Fodder will normally comprise different types of quality (palatability, nutrient contents, etc.). A part or all of the manure is normally returned to the field, contributing to maintaining soil fertility in the ecosystem, see Figure 3.2

Figure 3.2. **Provisioning of fodder for livestock**



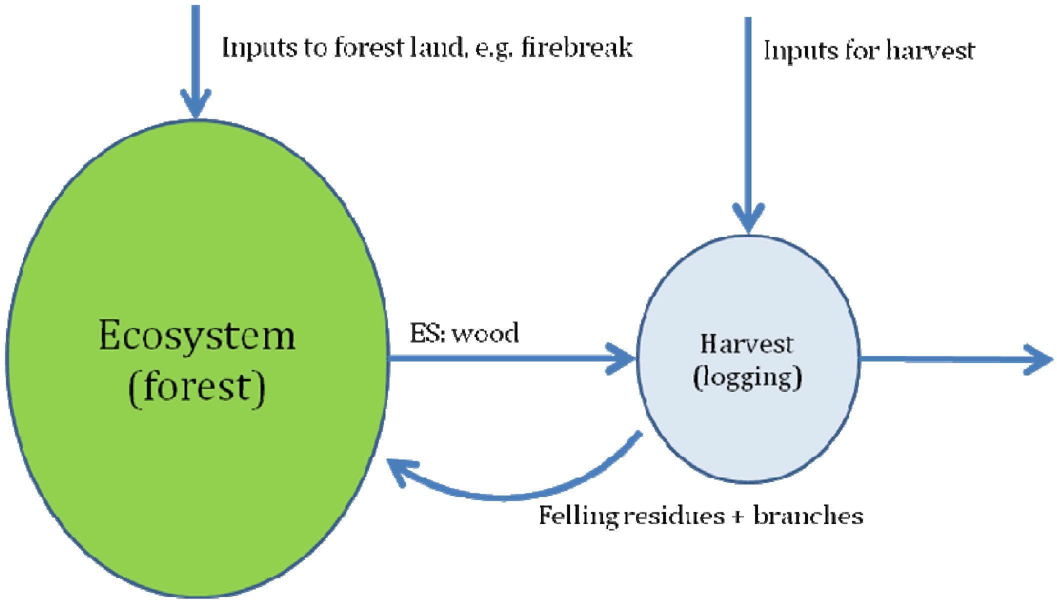
Provisioning of wood and non-timber forest products

3.39 Wood production includes the production of timber and firewood in natural, semi-natural or plantation forests. Non-timber forest products (NTFPs) include a broad range of products that can be harvested in a forest, such as fibres (e.g. rattan), fruits, mushrooms and pharmaceutical products. Plantation forests are considered cultivated biological resources and are evidenced by relatively significant levels of economic activity in the growing process including the construction of fire breaks, reforestation with specific species, the spraying of pesticides, and the thinning of branches to promote growth.

3.40 While the management practices may differ, the underlying ecosystem provisioning service is the same: the growing of the 'wood' or 'NTFP' that enters the production function of the logging company or individual. Figure 3.3 presents this service, focusing for illustrative purposes on the supply of wood.

3.41 For logging, a number of inputs are required such as labour, a saw and a truck. The product resulting from the logging is logged wood, with felling residues returned to the ecosystem. Wood can have a wide range of different qualities. Both the product (logged wood) and the ecosystem services (wood) can be measured in terms of kg/ecosystem/year. The difference between the two is that the ecosystem service represents standing wood at the moment immediately before it is felled, the product represents logged wood. For harvesting of NTFPs, only labour may be required, and the ecosystem service (i.e. NTFP immediately prior to collection) may be equivalent to the product (i.e. the harvested NTFPs).

Figure 3.3 Provisioning of wood

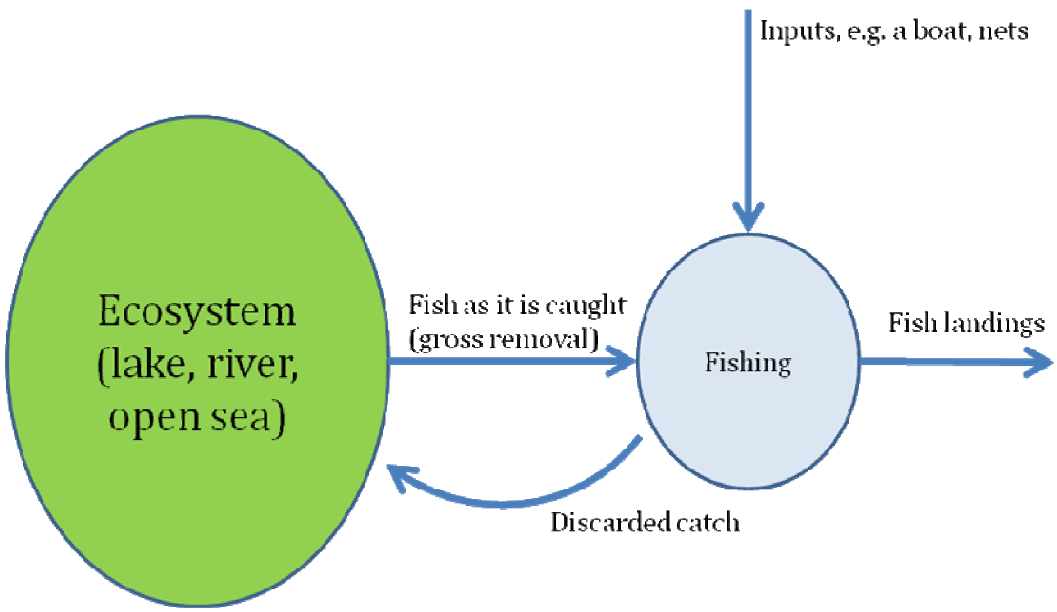


Provisioning of fish and other aquatic and marine species

3.42 Marine or inland waters (lakes, rivers) supply fish and other species (shrimps, shellfish, seaweed, etc.). There is generally little investment in maintaining the state of the ecosystem, even though monitoring or law enforcement activities may be undertaken, and on specific occasions also restocking of specific lakes may be carried out. However, inputs are required for the harvesting of fish and other species, involving boats, nets, labour, etc. The ecosystem service is the fish as it is harvested (corresponding to the 'gross removal'). The product resulting from the activity fishing is fish, most commonly expressed as landed fish.

3.43 The ecosystem service may be measured in physical terms in terms of the amount of fish caught (i.e. the gross removal from the ecosystem), accounting for differences in species, see Figure 3.4. Discarded catch is usually returned to the ecosystem. Often the discarded catch consists mainly of dead specimens that do not lead to a restocking of the ecosystem.

Figure 3.4. Provisioning of fish

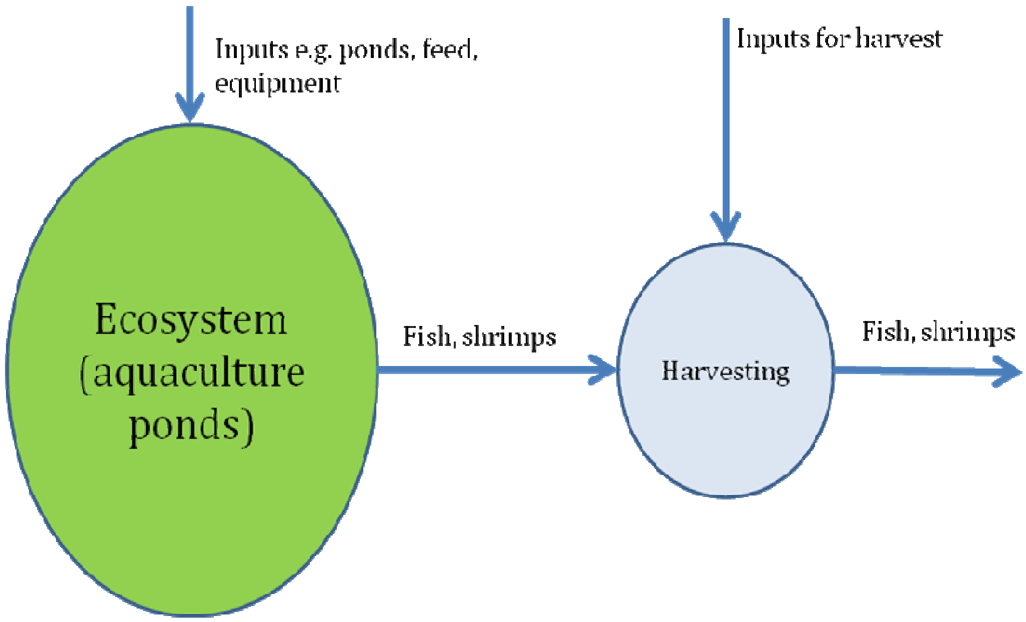


Provisioning of fish from aquaculture

3.44 Aquaculture systems range from highly extensive (blocked water bodies with some stocking of commercial varieties) to highly intensive (e.g. intensive shrimp ponds with controlled stocking, feeding, use of pesticides and other chemicals). As in the case of farming, in aquaculture there are investment required to shape the productive environment required for growing fish or crustacean production, for instance in ponds and infrastructure. In addition, inputs are required to harvest the crops, even though these may be small compared to the investment required for developing the aquaculture facility. In the case of aquaculture, there may not be any return of discarded fish to the ponds, and the harvested 'ecosystem service' may equal the product. Figure 3.5 shows the overall model for this ecosystem service.

3.45 The ecosystem service can be measured in terms of fish produced. In the case of aquaculture, there is a need to examine if harvesting systems can be classified as ecosystems (which may be appropriate for the extensive systems where natural processes including predation are important in regulating the ecosystem dynamics) or as purely produced systems (akin to greenhouses (as may be more appropriate for the most intensively aquaculture systems).

Figure 3.5 Fish and crustacean production from aquaculture



Provisioning of water

3.46 Freshwater can be extracted from deep or shallow aquifers, and from surface water including lakes, rivers or man-made reservoirs. The supply of water from deep aquifers is not strongly linked to ecosystem functioning since these reservoirs tend to depend on geological water resources. The extraction of water from deep aquifers storing water that is not replenished on human time scales should therefore be interpreted as extraction of sub-soil assets.

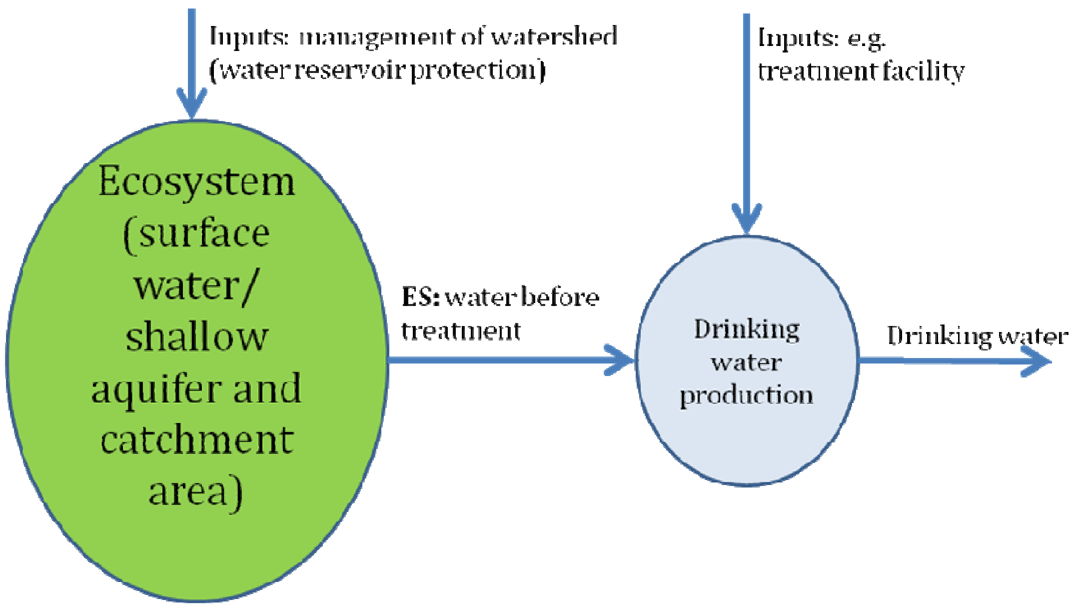
3.47 For both surface water and water extracted from renewable, shallow aquifers, both the quantity and the quality of water generally depend on ecosystem functioning. Water from rivers, lakes or other reservoirs may be purified by ecosystems, in particular if it has passed through a wetland that has the capacity to break down organic pollutants, and absorb inorganic pollutants. Water pumped up from aquifers or other subsurface groundwater sources is often less polluted than surface water because of the capacity of ecosystems to breakdown or bind pollutants and filter micro-organisms harmful to human health. Often, headwaters or complete watersheds important for drinking water production are protected and managed as drinking water extraction area.

3.48 Water supply therefore combines elements of a provisioning and a regulating service. It is a provisioning service in the sense that the extraction of water involves the flow of a good from the ecosystem to society, however underlying the presence of the water are a number of regulating processes such as water storage (inter or intra-annual) and water purification.

3.49 The water accounts presented in the SEEA Central Framework and in SEEA-Water detail the methods for accounting for water resources including deep aquifers. In contrast, in SEEA Experimental Ecosystem Accounts, the focus is on ecosystems' capacity to support water extraction. The approach taken is to analyse the provisioning of water as an ecosystem service is illustrated in Figure 3.6 below. The ecosystem service is the amount of water (before treatment) extracted from the surface water source or the shallow aquifer.

3.50 Investments may be made in order to protect the ecosystem (generally a watershed) supplying the water (e.g. adjusted land management, monitoring of water quality, creation of retention basins) as well as for the transformation of extracted water into drinking water. The extracted, untreated water enters the production function of the drinking water company, or of the household consuming the water. The household may either consume this water directly, or filter it before consumption.

Figure 3.6 Provisioning of water



3.4.2 Regulating services

3.51 Typical for regulating services that they involve a process regulated by the ecosystem that provides a non-material benefit to society in the form of lowering the risks of certain negative outcomes (such as polluted air). However, typical for this category of services is that a range of conditions and factors need to be in place before a benefit is received. Thus, the processes regulated by the ecosystem only constitute a benefit - and therefore an ecosystem service - in situations where the ecosystem processes affects people. For instance, air filtration by vegetation only materialises as an ecosystem service if there is air pollution in the atmosphere that the vegetation is absorbing <u>and</u> if there are people living nearby that benefit from a lower concentration of air pollutants.

3.52 These other conditions and factors have been called, for the purpose of SEEA Experimental Ecosystem Accounts, ‘enabling factors’. These enabling factors differ for the various regulating services, and are described below for three regulating services. Note that these enabling factors are typically not an attribute of the ecosystem, and they are not reflected in the stock of ecosystem capital. Nevertheless, these factors need to be understood, quantified and recorded before physical and monetary quantification of the ecosystem service can take place.

3.53 The delivery of regulating services is commonly and increasingly affected by land use choices made by producers and society generally. At a local level the delivery of regulating services may be affected negatively by the removal of vegetation, for example. Equivalently, the delivery of regulating services may be enhanced by the planting of vegetation or the protection of existing vegetation. Thus, while the regulating services themselves are very much natural processes, the extent of their delivery can be materially affected by human activity.

3.54 The paragraphs below present a brief description of selected regulating services. They also contain a figure that illustrates the supply of ecosystem services by the ecosystem, as well as the role of other inputs (such as labour and produced assets) and the subsequent benefits. In the case of regulating services, there are no activities required to produce the service.

Sequestering of carbon and carbon storage

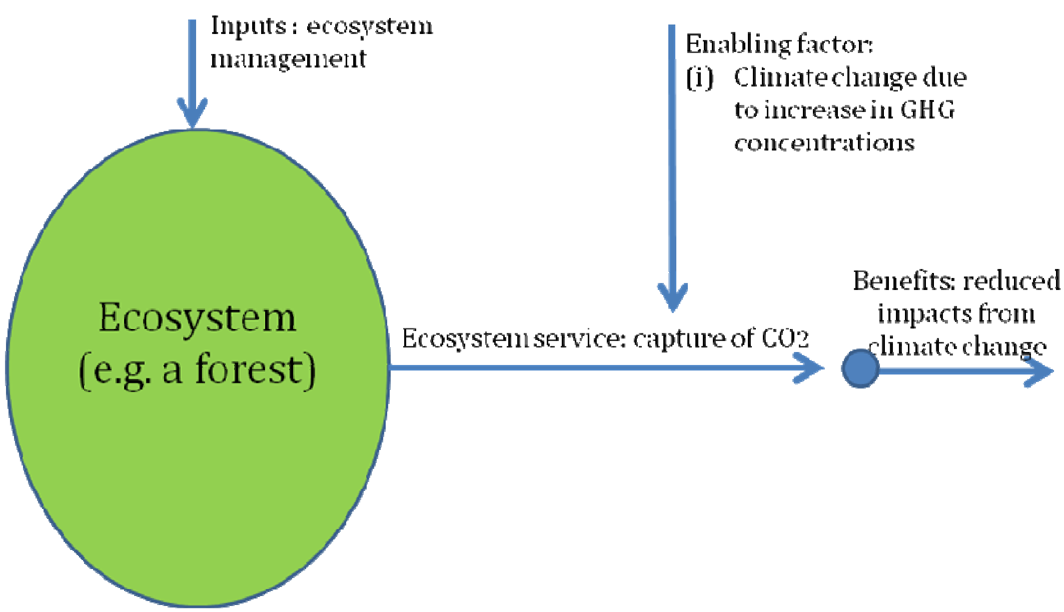
3.55 Often, the services of sequestering of carbon and carbon storage are labelled by the single term “carbon sequestration”. However, they are quite different ecosystem services, albeit linked within the broader carbon cycle. Both services are important for ecosystem management and therefore for ecosystem accounting. The release of carbon stored in above ground biomass or in below ground stocks, such as peatlands, is an important source of greenhouse gas emissions worldwide. It is also the subject of much debate in the international arena, in particular with regards to the REDD (Reduced Emissions from Deforestation and Degradation) payment mechanism. At the same time, the sequestering of carbon, i.e. the ongoing accumulation of carbon due to ecosystem processes in particular Net Ecosystem Production, is relevant since this removes carbon dioxide from the atmosphere.

3.56 In order to capture both the stock and the flow aspect of carbon, the following conceptualisation of this ecosystem service is used for the purpose of ecosystem accounting. Analogous to other ecosystem services, the sequestering of carbon and carbon storage are service flows that can only have positive values. In both cases the flows is expressed as tons of carbon(equivalent)/year, and should be specified for spatially defined areas that can be aggregated for the purpose of national level ecosystem accounting. The service of the sequestering of carbon is equal to the net accumulation of carbon in an ecosystem due to growth of the vegetation and due to accumulation in below ground carbon reservoirs. The ecosystem service of carbon storage is the avoided flow of carbon resulting from maintaining the stock of above ground and below ground carbon sequestered in the ecosystem.

3.57 To calculate the second part, i.e. the flow that can be attributed to maintaining carbon in storage, the avoided emissions are calculated. These avoided emissions only relate to the part of the stored carbon that is of clear risk of being released in the short term due to land use changes, natural processes (e.g. fire) or other factors. No service is delivered if all stocks at risk of being released are released but positive service flows are recorded where stocks at risk remain in storage.

3.58 The conceptual model of the ecosystem service as a function of ecosystem state and enabling factors is presented in Figure 3.7. Figure 3.7 shows that ecosystem management will generally affect the net sequestration and/or the storage of peat in the ecosystem. The enabling factor for this service is the occurrence of climate change, which causes carbon sequestration and storage to provide an economic benefit resulting from avoided damages, at present and in the future.

Figure 3.7 Sequestering of carbon



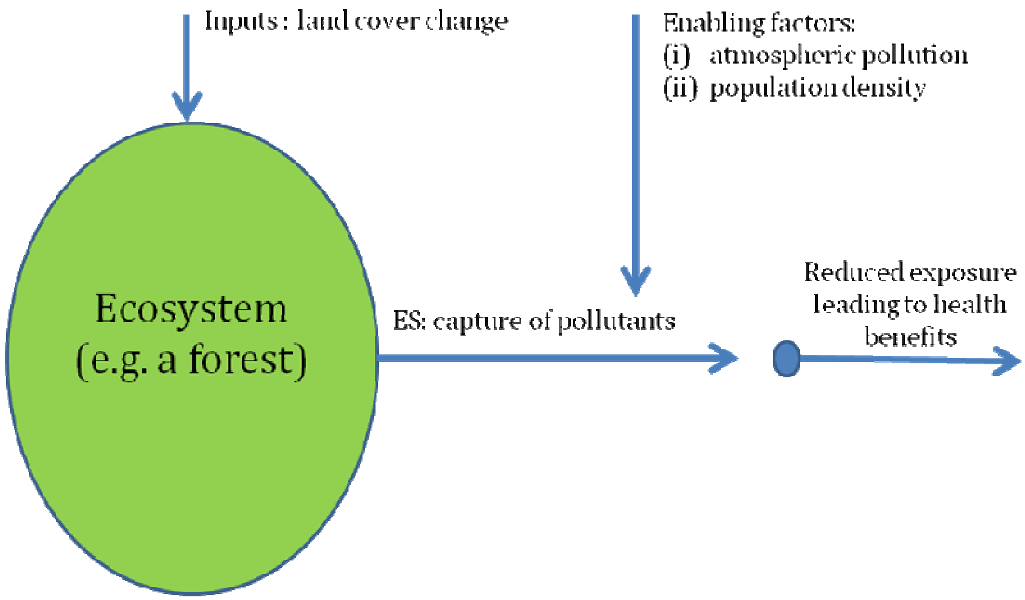
Air filtration

3.59 Air pollution arising from particulate matter (in particular the smallest fraction of PM: PM2.5 with a diameter <2.5 µm) is a major health problem in many countries. Statistically significant relationships between PM concentration and cardiovascular and respiratory diseases, as well as lost working days due to air pollution-related illnesses have been shown in a range of studies. Air pollution removal takes place through the interception of PM by leaves (dry deposition). The amount of interception depends on the state and management of the ecosystem (for instance, on an annual basis evergreen trees capture more PM than deciduous trees). Two enabling factors are needed to turn the ecosystem process of deposition into an ecosystem service. First there needs to be a certain pollution load (that can be measured in terms of PM concentration) and second there need to be an exposure of people to air pollution in the zone affected by PM deposition by the ecosystem.

3.60 The total amount of particulate matter deposited in an ecosystem can be estimated as a function of the area, deposition velocity, time period and average ambient PM2.5 concentration, according to the formula PM↓ = A*Vd*t*C, in which PM↓ = deposition of PM2.5 (kg), A= area (m^2), Vd = deposition velocity as a function of the Leaf Area Index of the vegetation (LAI) (mm s^{-1}), t= time (s), and C = ambient PM2.5 concentration (kg/m3). The deposition velocity depends on the vegetation type, and there is an increasing number of measurements of deposition velocities as a function of vegetation type, in particular in European countries.

3.61 A cause of uncertainty pertains to the distance at which vegetation influences air quality. The UK NEA assumed that health benefits from air filtration by forests only occur at short distances (<1 km) from the forest. Other studies states that damage assessments of particulate matter pollution need to consider that air pollution (PM) can spread over distances of several hundreds of kilometres from an emission source, which means that the effect of large forests on air quality may be noticeable at larger distances from the forest edge.

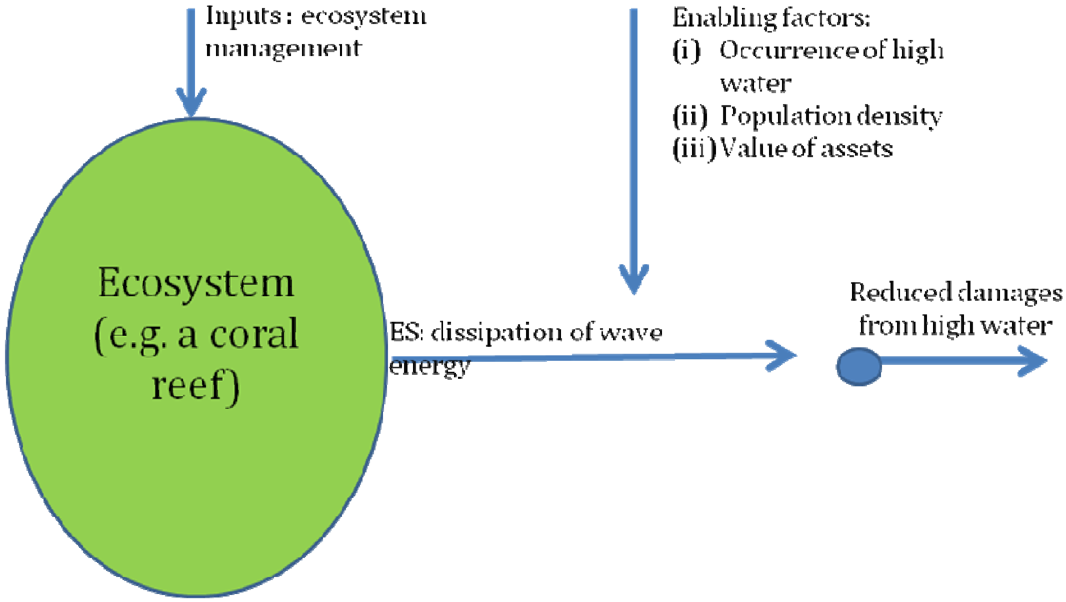
Figure 3.8 Air filtration



Flood protection

3.62 It is clear from a range of studies that specific ecosystems can reduce the extent and intensity of floods, thus reducing the risk of damage to built environments and other ecosystems. Ecosystems such as mangroves, dunes or coral reefs, or riparian forests, are particularly relevant in this regard. This service is only relevant where there is (i) risk of high water and wave energy as a function of wind patterns and local bathymetrics; and (ii) the presence of people, economic activity and assets susceptible to loss in the exposed flood risk zone. Storm occurrence and therefore flood risk may be modelled in a probabilistic manner, on the basis of the occurrence and magnitude of storms in recent decades and on the basis of climate models accounting for climate change. In coastal areas, the ecosystem service involves the dissipation of wave energy and the prevention of inundation. In inland areas, the ecosystem service involves the channelling and dispersion of water.

Figure 3.9 Flood protection



3.4.3 Cultural Services

3.63 Cultural services are more difficult to scope than provisioning and regulating services since they reflect the nature of human relationships with ecosystems rather than more direct extraction or use of ecosystem processes. At the same time there are some cultural services that are quite obvious, particularly tourism and recreation services, and the benefits that arise from these services are often an important part of economic activity.

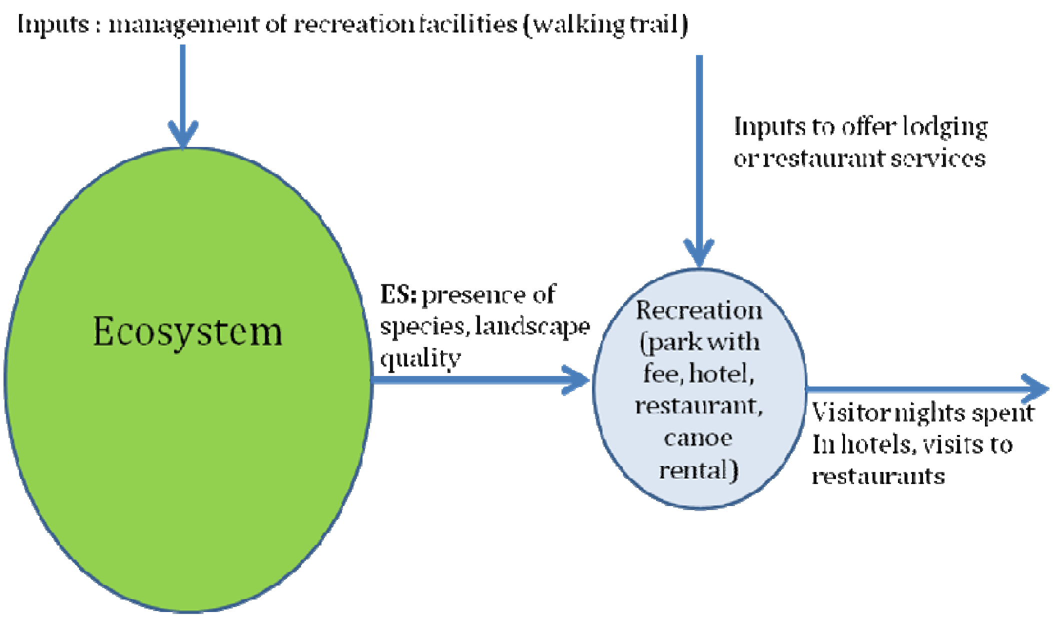
3.64 For those cultural services that are not within scope of the SNA production boundary, the aim is to define the amenity or utility that people derive from the landscape. For many people, particularly indigenous peoples, this may be strongly spiritual and cultural. In general terms, the extent of these services will be a function of human access to the ecosystem (perhaps based on the number of people interacting with the ecosystem) and the quality of the ecosystem and surrounding landscape.

Tourism and recreation

3.65 Ecosystems provide an opportunity for tourism and recreation. Tourism is generally interpreted as involving overnight stays, potentially from visitors abroad, and recreation is more usually associated with day trips. The service requires some degree of investment in the ecosystem, for instance to lay out walking trails, cycling paths, and camping sites. In physical terms, this ecosystem service can be measured in terms of the number of people visiting the ecosystem. The benefits accrue to visitors themselves, and to nearby suppliers of tourism and recreational facilities to the extent that they can attribute their operation to the ecosystem. For instance, some tourism facilities can only exist because of the presence of the ecosystem, as in the case of an enterprise renting out skis or canoes. For other enterprises, the picture is mixed, and only part of their activity may be attributable to the ecosystem, as in the case of hotels or restaurants located in or nearby natural parks.

3.66 Physical measurement of the ecosystem involves recording the number of visitors, in terms of visitor-days, or overnight stays, to ecosystems. Ecosystems such as national parks that are publically accessible are most relevant for this service. As in the case of provisioning services, the use of ecosystem services in tourism involves a specific activity being undertaken, i.e. the recreation activities by people in an ecosystem.

Figure 3.10 Tourism and recreation services



3.4.4 Ecosystem services and biodiversity

3.67 The relationship between ecosystem services and biodiversity is complex and difficult to conceptualise and measure. On the one hand, biodiversity is a core characteristic of ecosystems much akin to supporting services. However, many people also value species diversity and/or the protection of rare species independent of the role of these species in supplying other ecosystem services. Even though the service is difficult to measure and record, it is complementary to other ecosystem services and is therefore included in the framework.

3.68 Biodiversity is generally assumed to include the three levels of genetic, species and ecosystem diversity. Hence biodiversity is not equivalent to nature nor does it necessarily fully represent the natural value of an ecosystem. For instance the preservation of a conservation flagship species, for instance the orang-utan, may be perceived to be more important than the preservation of a rare beetle, even though the extinction of both species would reduce biodiversity by one species.

3.69 A measurement consideration is that the preservation of some species may be important for the overall functioning of the ecosystem, in particular where it concerns species that occupy a specific role or trophic niche in the ecosystem. Ecological theories indicate that maintaining species diversity within functional groups is important for ecosystem functioning and resilience.

3.70 The measurement of biodiversity is generally in the form of indexes that focus on species or protected areas. A measurement framework for biodiversity and the key indicators that can be used in ecosystem accounting is discussed in Chapter 4.

3.5 Setting priorities for selecting ecosystem services in ecosystem accounts

3.71 In piloting ecosystem accounting at the national scale, it may be most feasible to initially select a limited rather than a comprehensive set of ecosystem services for inclusion in ecosystem accounts. The potential feasibility to measure ecosystem services at the national scale, both in physical and in monetary terms, differs strongly between different ecosystem services. These differences occur due to differences in data availability, different methodological constructions, and different complexities related to scaling up and aggregating physical and monetary units associated with ecosystem services. In addition, there may be different policy priorities for analysing ecosystem services.

3.72 To facilitate the selection process of ecosystem services in ecosystem accounts, a list of criteria for ranking ecosystem services with regards to their potential suitability for inclusion in ecosystem accounting is presented in Table 3.6 below. The applicability of the criteria will differ between countries and the list should be seen as indicative only.

Table 3.6 Criteria for prioritization of ecosystem services for accounting purposes.

	Criterion	Brief explanation
1	Availability of broadly accepted methods for analyzing ecosystem services supply in physical terms at a high aggregation level	Initial consideration may initially be given to services for which broadly accepted modelling / quantification techniques are available.
2	Availability of broadly accepted methods for analyzing ecosystem services supply at a high aggregation level in monetary terms	Initial consideration may initially be given to services for which broadly accepted valuation approaches are available.
3	Availability of data for measuring ecosystem services in physical terms	Producing national level accounts will often require scaling up parcel level estimates of ecosystem services to a national level based on underlying spatial data. Both point-based data and spatially explicit data (e.g. land cover, soils, water tables, ecosystem productivity, etc.) are required to analyse a service at the national level.
4	Availability of data for measuring ecosystem services in monetary terms	
5	Plan to generate new data on ecosystem services supply	A firm intent or high likelihood that new environmental monitoring will provide essential data.
6	Economic importance of the ecosystem service.	Initial consideration may be given to those services that generate the highest economic benefits.
7	Possibility to influence environmental and/or economic policy and decision making (decision making context)	Initial consideration may be given to services that can relatively easily be influenced by decision making in order to have maximum relevance for policy making.
8	Sensitivity of the service to changes in the environment, including from anthropogenic stressors.	Initial consideration may be given to services that are sensitive to environmental change / well reflect changes in natural capital stocks.
9	Likelihood of irreversible loss of ecosystem services including by the supplying ecosystem being pushed past a significant threshold and out of its "safe operating range".	Initial consideration may be given to services that are generated from ecosystems that are generally understood to be close to significant environmental thresholds.

3.73 Data availability and policy priorities will differ per country, hence the selection of ecosystem services for ecosystem accounting will differ per country. In general, from a methodological and data perspective, most feasible for ecosystem accounting are the provisioning services including water supply and carbon sequestration, as described below.

3.74 *Provisioning services.* Since many provisioning services are already included in SNA, there is generally high potential to link these service to ecosystems.

3.75 Data on water resources is partly available, in particular regarding the production volumes of drinking water and to some extent irrigation water. However, the link between ecosystem management and water provisioning is less clear, with regards to such aspects as water purification in aquatic ecosystems or in the soil, water storage in ecosystems in upper watersheds, etc. Given the economic importance of water supply and the declining water resources in many parts of the world, including this service in ecosystem accounts may be a priority in many countries. A challenge is to better understand, in particular at high aggregation levels, the infiltration, purification and storage processes involved.

3.76 *Sequestering carbon and carbon storage.* Recent years have seen a strong increase in interest in the carbon related ecosystem services and there is a large amount of research on-going aimed at quantifying these services at different scales, from local processes to national stocks and flows. The development of REDD (Reduced Emissions from Deforestation and Degradation) market mechanisms means that there is also, increasingly, information available on markets related to carbon. Given the broad interest and the increasing availability of methods and data relevant for this service, this service has a high potential for inclusion in ecosystem accounts.

3.77 A challenge with regards to this service is to account for both the storage and the sequestering of carbon. Storage and sequestering are not aligned. A high carbon stock may mean that sequestration is limited because the vegetation is close to its maximum biomass under the ecological conditions pertaining in the particular area. A low carbon stock may mean that there is scope for additional sequestration (e.g. in a recently cut forest with intact soil fertility), but this doesn't have to be the case (e.g. in a desert).

3.78 It should be noted however, that although scientific methods and data are relatively well developed for this service, this does not equally apply to all ecosystems, with relatively much data available for forests, and relatively few data for lakes and coastal systems. There may also be data and/or methodological constraints related to analysing carbon sequestration in degraded forests and in forest/landscape mosaics.

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DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS
STATISTICS DIVISION
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Seventh Meeting of the UN Committee of Experts on Environmental-Economic Accounting
Rio de Janeiro, 11-13 June 2012

SEEA Experimental Ecosystem Accounts

Accounting for ecosystem capital in physical terms:
Annotated outline of Chapter 4 SEEA Experimental Ecosystem Accounts

(for discussion)

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

SEEA Experimental Ecosystem Accounts

Draft material prepared for the 7th Meeting of the Committee of Experts on Environmental-Economic Accounting (UNCEEA)

Meeting in Rio di Janeiro, Brazil 11-13 June, 2012

DRAFT

Accounting for ecosystem capital in physical terms:

Annotated outline of Chapter 4 SEEA Experimental Ecosystem Accounts

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 4

Work on the measurement of ecosystem capital has identified three approaches of relevance for ecosystem accounts. While all three approaches are related discussion is ongoing to determine the precise relationships between the approaches and whether any approach holds significant advantages over the others. Good discussion on this topic took place at the expert group meeting in Melbourne and there are clear signals that convergence on appropriate measurement approaches can be found.

It is anticipated that draft text should be able to be completed quite soon. This text would then for the basis for further discussion of the alternative approaches with accountants, ecosystem scientists and others with an interest in this work.

A particular aspect that will be reinforced is the relationship between the assessment of ecosystem capital and the measurement of ecosystem services, as described in Chapter 3. It is this link that provides the strong accounting connections between stocks and flows that is at the heart of the SEEA accounting approach.

Draft text on accounting for carbon and accounting for biodiversity is well advanced and these two topics have been regularly discussed at expert group meeting through the past 18 months. Importantly, good connections have been made to the broader communities with specific interest in carbon accounting and accounting for biodiversity (for example with researchers connected to the Convention on Biological Diversity (CBD)).

Annotated outline

Chapter 4: Accounting for ecosystem capital in physical terms

4.1 Introduction

This section is to provide the appropriate context for the accounting for ecosystem capital in particular making note of the need to make assessments of ecosystem capital that are indirect and hence based on assessment of different components and characteristics of ecosystems in both quantitative and qualitative terms.

4.2 General logic of a component based approach to ecosystem assessment

This section provides an explanation of the basic approach to measuring ecosystem capital where the capacity of an ecosystem to provide ecosystem services is a function of the ecosystems extent and its condition. This basic approach extends to an explanation of the consumption of ecosystem capital (degradation).

The section also introduces the three ways in which this basic approach might be measured – via a focus on ecosystem services, via a focus on ecosystem condition, and via a focus on ecosystem processes and characteristics.

4.3 Description of approaches to measuring ecosystem capital

This section gives an overview of the methods available for the assessment of ecosystem capital using as the starting point the three ways of measuring ecosystem capital outlined in Section 4.2. At this stage, no recommendation is provided on the preferred approach. All three approaches will be discussed further with relevant experts, and, as appropriate advice on the potential and the limitations of the methods will be provided.

4.4 Compiling ecosystem capital accounts

Within the boundaries of the three approaches to the measurement of ecosystem capital, this section provides some direction in the compilation of ecosystem capital accounts. These accounts aim to organise non-monetary information on the extent, condition and capacity of ecosystems to generate ecosystem services into the future.

An important focus of this section is discussion of approaches to the formation of overall assessments of ecosystem capital in non-monetary terms using information on a range of different ecosystem components and characteristics and combining measures of quantity and quality. In this regard, the use of index numbers and the development of common measurement units to compare aspects of ecosystem capital are relevant measurement topics that require discussion.

4.5 Examples of ecosystem capital accounts for selected ecosystem types

Similar to the structure of Chapter 3, it is planned that some examples of possible ways to structure an ecosystem capital account might be presented focused around particular examples of ecosystems – e.g. forests, agricultural land.

4.6 Accounting for carbon &

4.7 Accounting for biodiversity

These sections have been included to highlight the potential to apply the constructs of ecosystem accounting in two important areas of carbon and biodiversity. As well, accounting in these two areas feedback into the development of ecosystem accounts.

Key parts of the section on accounting for carbon are

- Motivation for accounting for carbon and purposes of carbon accounts
- Description of the carbon cycle
- Description of a carbon stock account covering stocks and changes in stocks of stores of geo- and bio-carbon – including discussion of carbon stores of different quality (links also to approaches to assessing ecosystem capital – Chapter 4)
- Discussion of issues surrounding carbon sequestering, carbon storage and avoided emissions (link to Chapter 3 on ecosystem services)
- Discussion of issues on related indicators – net carbon balance, net primary productivity, resource efficiency, links to IPCC data and processes

Key parts on the section on accounting for biodiversity are

- Motivation for accounting for biodiversity and purposes of biodiversity accounts
- Definition and description of biodiversity
- Description of an overall model for structuring information on biodiversity at a national level (by ecosystem, by species, etc)
- Description of a species account

- Summary of key biodiversity indicators (in particular CBD indicators)
- Discussion of links to measurement of ecosystem services and ecosystem capital

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SEEA Experimental Ecosystem Accounts

Chapter 5: Approaches to valuation for ecosystem accounting

(for discussion)

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Chapter 5: Approaches to valuation for 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 5

It is intended that the valuation basis to be applied in the SEEA Experimental Ecosystem Accounts is consistent with the SNA and the SEEA Central Framework, i.e. market prices. At the same time the nature of ecosystems and the flows of ecosystem services means that valuation using observed, transaction based market prices is usually not possible. Thus, the question that must be answered is the extent to which alternative valuation methods that might be used for valuation purposes in ecosystem accounting are consistent with the SNA principles.

The intention in this chapter is to tackle this question in the following way.

> First, to outline clearly the SNA and SEEA principles on valuation. While at one level this may be seen as limited to observed market prices, the SNA describes at some length approaches to valuation where non-monetary transactions are constructed and where imputed prices must be used. Of particular relevance in the context of ecosystem accounting is the valuation of public goods – which are valued using the costs of production following the SNA.
>
> Second, to describe the various valuation approaches that have developed and been applied in ecosystem accounting for the purposes of compiling monetary estimates of ecosystem services.
>
> Third, to assess the various approaches in terms of their consistency with the SNA valuation principles.
>
> Fourth, as appropriate and to the extent possible, to provide examples of the valuation of selected ecosystem services using relevant approaches.

At this time, material has been drafted concerning the first two matters on valuation principles and valuation approaches, noting that more work may be needed to ensure an appropriate coverage of alternative valuation approaches. The third stage of reviewing the various approaches in light of the valuation principles has not been completed although discussion on this topic did occur at the Expert Group meeting on Ecosystem Accounts held in Melbourne in mid May, 2012.

It is intended that discussions will be held with both national accountants and economists involved in the valuation of ecosystem services in the coming months. Draft material on the application of valuation approaches to specific ecosystem services will be developed as appropriate.

Chapter 5: Approaches to valuation for ecosystem accounting

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Chapter 5: Approaches to valuation for ecosystem accounting

5.1 Introduction

To be drafted

5.2 Valuation principles in the SNA and the SEEA

General principles of valuation

5.1 For accounts in monetary terms the question of valuation is central. This paper provides an introduction to the principles of valuation that are used in the SNA and that are adopted in the SEEA. In the SEEA, as in SNA, the values reflected in the accounts are, in principle, the current transaction values or market prices for the associated goods, services, or assets that are exchanged. (2008 SNA, 3.118)

5.2 Strictly, market prices are defined as amounts of money that willing purchasers pay to acquire something from willing sellers. The exchanges should be made between independent parties on the basis of commercial considerations only, sometimes called “at arm’s length”. (2008 SNA, 3.119)

5.3 Defined in this way, a market price should be distinguished from a general market price that gives an indication of the “average” price for exchanges in a type of good, service or asset. In most cases, market prices based on the totality of transactions that actually occur will approximate the general “average” market prices just described.

5.4 There is a range of situations in which valuation is relevant. The two primary situations for the SEEA Experimental Ecosystem Accounts are the valuation of flows of ecosystem services and the valuation of ecosystems themselves. The measurement of the value of the flow of ecosystem services falls within a general SNA category of valuing transactions. The valuation of ecosystems falls within the SNA category of valuing assets. Each of these areas of valuation is discussed in turn noting that in both cases the general principle outlined above is applied.

Valuation of transactions

5.5 Following SNA, a transaction is an economic flow that is an interaction between institutional units (e.g. between corporations, households, governments) by mutual agreement or an action within an institutional unit that is analytically useful to treat like a transaction. (2008 SNA, 3.51) Mutual agreement does not imply the transaction is voluntarily entered into by both parties (for example, payments of taxation are obligated by law), rather mutual agreement implies the prior knowledge and consent of the parties. (2008 SNA, 3.53)

5.6 A large proportion of transactions are monetary transactions in which one institutional unit makes a payment (or receives a payment) stated in units of currency. Common monetary transactions include expenditure on the consumption of goods and services; payments of wages and salaries; and payments of interest, rent, taxes, and social assistance benefits. In many cases these monetary transactions represent “something for something” transactions – i.e. there is a *quid pro quo*. In other cases, for example taxes and social assistance benefits, no *quid pro quo* is involved. These transactions are known as transfers.

5.7 In the context of measuring ecosystem services the measurement of monetary transactions is not of direct relevance since there are no payments to an ecosystem in exchange for the various ecosystem services. Often there may be monetary transactions associated with the benefits obtained from the use of ecosystem services (for example sales of landed fish) but the connection with the value of the services is not direct. Consequently, of most relevance in the valuation of ecosystem services are the approaches to the measurement of non-monetary transactions.

5.8 Non-monetary transactions are transactions that are not initially stated in units of currency. The value of these transactions must therefore be indirectly measured or otherwise estimated. In some cases a transaction may be an actual one and a value has to be estimated to record it in the accounts. Barter transactions are a good example. In other cases, the entire transaction must be constructed and then a value estimated for it. These constructed transactions are referred to as imputed transactions. (2008 SNA, 3.75).

5.9 An important imputed transaction in the national accounts is the measurement of consumption of fixed capital (depreciation). This is constructed since the flow is one that is internal to an institutional unit and no actual monetary flows occur. Depreciation must therefore be estimated and this is done based on a range of information and assumptions concerning rates of value decline, estimated asset lives, likely replacement costs, etc.

5.10 Another good example of imputed transactions in the national accounts concerns the internal actions of households that are considered analytically useful to treat as transactions. For households, the production boundary of the SNA is defined such that all goods produced by persons within a household that are subsequently used by members of the same household for the purposes of final consumption are included in measures of output in a manner analogous to that for goods sold on the market. Examples of these goods include the growing of crops and animals for own consumption; fish and other animals caught; the collection of timber for use as fuelwood; the abstraction of water; and the building of furniture and making of clothes. In all of these cases, the activity is within the production boundary of the SNA and should be recorded even though no monetary exchange takes place.

5.11 In accounting terms this means that transactions must be constructed in which persons responsible for the production of the goods are deemed to deliver the goods to themselves (or members of their household) as consumers. Values must then be associated with them in order to enter them in the accounts. (2008 SNA, 3.87) The same logic also extends to the housing services produced by those households that own and occupy their dwelling – a transaction commonly referred to as imputed rentals.

5.12 With reference to ecosystem services, the logic of constructing transactions for these services has been outlined in Chapters 2 and 3, although it was not presented from that perspective. Put in terms of the definition of transactions, flows of ecosystem services represent flows internal to an institutional unit or broader production function that are "analytically useful to treat like a transaction" (2008 SNA 3.51). The following paragraphs consider approaches to estimating values for non-monetary transactions that are discussed in the SNA.

Approaches to valuing non-monetary transactions

5.13 When market prices are not observable, valuation according to market-price-equivalents provides an approximation to market prices. In such cases, market prices of the same or similar items when such prices exist will provide a good basis for applying the principle of market prices. Generally, market prices should be taken from the markets where the same or similar items are traded currently in sufficient numbers and in similar circumstances. If there is no appropriate market in which a particular good or service is currently traded, the valuation of a transaction involving that good or service may be derived from the market prices of similar goods and services by making adjustments for quality and other differences. (2008 SNA, 3.123)

5.14 An example of this approach is the valuation of imputed rentals of owner-occupiers whereby, in general terms, the actual rentals paid by non-owner occupiers, provide the basis for the estimation of the imputed rentals paid by owner-occupiers. So that the value of the housing services can be measured as accurately as possible, adjustments are usually made for the location and size of the dwellings (e.g. by modelling actual rentals paid in different suburbs or regions and for houses with different numbers of bedrooms).

5.15 Where no sufficiently equivalent market exists and reliable market prices cannot be observed, a second best procedure must be used in which the value of the transaction is deemed equal to the sum of the costs of producing the good or service, i.e. the sum of intermediate consumption, compensation of employees, consumption of fixed capital (depreciation), other taxes (less subsidies) on production, and a net return on capital. (2008 SNA, 6.125)

5.16 The economic rationale for the use of the "cost of production" approach is that unless the producer can cover their costs, including covering the full user costs of capital (i.e. deprecation and net return), the production should not take place and hence the good or service would not be available on the market. In the absence of information to the contrary this is considered a reasonable assumption. Significantly, this approach to estimating market prices provides a decomposition of the concept of an SNA market price that is amenable to estimation.

5.17 In the context of ecosystem services, the economic rationale for the cost of production approach can be applied by using the components of a market price (i.e. the various costs of production) to decompose observed market prices for the benefits produced using ecosystem services. Thus, for example, the observed market price of a landed fish may be decomposed into its constituent costs of production, one of which will be the implicit cost of the fish itself from the ecosystem. This implicit cost represents the resource rent for the fish and may be considered a price for the ecosystem service. The measurement of resource rent is discussed in detail in the SEEA Central Framework in Chapter 5.

5.18 In the discussion to this point the underlying assumption is that the producers operate to secure a reasonable net return and participate in production cognisant of the market prices and associated costs of production. This assumption applies for both monetary and non-monetary transactions. Thus, for example, concerning the imputed rentals of owner-occupiers, it is assumed that the owners make a conscious choice to own the dwelling and hence avoid paying actual rentals to a landlord and in effect become their own landlord operating in the housing market.

5.19 At the same time the SNA recognises that there are a significant number of producers, particularly government producers, who do not operate with this market based rationale. Consequently, there are many goods and services, for example health and education services, that in many countries are provided for free or at nominal costs to the users. This type of production of goods and services is known as non-market production.

5.20 The SNA considers that the prices paid (including zero prices) for the output of non-market producers are not economically significant and may reflect neither relative production costs not relative consumer preferences. These prices therefore do not provide a suitable basis for valuing the outputs of the goods and services concerned. (2008 SNA, 6.130) Instead, the value of non-market output is estimated as the sum of costs of production as outlined above with the exception that, by convention, no net return on capital in included in the valuation. (2008 SNA, 6125)

5.21 In the context of ecosystem services, the valuation convention for non-market output of excluding a net return on capital implies that choices should be made as to whether the ecosystem services are considered part of market or non-market output.

Valuation of assets

5.22 Assets, strictly economic assets in an SNA context, are stores of value representing a benefit or series of benefits accruing to the economic owner by holding or using the entity over a period of time. (2208 SNA, 10.8) The prices at which assets are bought or sold on markets are a basis of decisions by investors, producers, consumers and other economic agents. Market prices are assessed by investors and producers in relation to their expectations of the flows of income they can derive from the assets. For example, investors in renewable energy infrastructure assets (such as wind turbines) and environmental assets (such as land) make decisions in respect of acquisitions and disposals of these assets in the light of their values in the market relative to the income they expect the assets to generate over time.

5.23 Ideally, observable market prices should be used to value all assets and every item should be valued as if it were being acquired on the date to which the estimate of the stock relates (usually the beginning and end of an accounting period). These two recommendations enable the values of different types of assets, including environmental, financial, and other economic assets to be compared in meaningful ways, and allow the formation of opening and closing values of stocks that can be used to assess national and institutional sector estimates of wealth in monetary terms.

5.24 The ideal source for asset prices are <u>values observed in markets</u> in which each asset traded is completely homogeneous, often traded in considerable volume, and has its market price listed at regular intervals. Such markets yield data on prices that can be multiplied by indicators of physical stocks in order to compute the total market value of different classes of assets. These types of price observation are available for most financial assets, newly purchased produced assets including many types of transport equipment (such as cars and trucks), and livestock.

5.25 In addition to providing direct observations on the prices of assets actually traded, information from such markets may also be used to price similar assets that are not traded. For example, information on house and land sales may be used to estimate the value of houses and land that have not been sold.

5.26 It is noted that in some cases, observed market prices may cover the values of a number of assets. For example, prices for real estate will usually include both a value for the dwelling (or buildings) on a piece of land as well as a value for the land itself (in particular its size and location). The notion of composite assets is one that is explained further in SEEA Central Framework Section 5.6 and is of relevance in the context of ecosystems which, by definition, represent a combination of bio-physical components.

5.27 When there are no observable prices because the items in question have not been purchased or sold on the market in the recent past, an attempt has to be made to estimate what the prices would be if a regular market existed and the assets were to be traded on the date to which the estimate of the stock relates. There are two main approaches that are described in the SNA to deal with this situation.

5.28 The first approach is to use the written down replacement cost. The value of certain types of assets (primarily produced assets) will decline over time as the value at the time of acquisition, the acquisition price, is reduced by consumption of fixed capital (more commonly referred to as depreciation) over the asset's life. Furthermore, the acquisition prices of equivalent new assets will change. In theory, the value of an asset at any given point in its life is equal to the current acquisition price of an equivalent new asset less the accumulated consumption of fixed capital over its life. (2008 SNA, 13.23)

5.29 When reliable, directly observed prices for used assets are not available, this approach gives a reasonable approximation of what the market price would be were the asset to be offered for sale. The written down replacement cost approach is used in most countries to estimate the value of the fixed capital stock (i.e. the stock of produced assets such as buildings, houses and machinery and equipment). Consequently, this approach underpins measures of consumption of fixed capital used in the national accounts (for example to estimate the value of government output) and also measures of multi-factor productivity derived following a growth accounting approach.

5.30 In the context of environmental assets, this approach may be applied to estimate the value of the stock of cultivated biological resources that are fixed assets, for example, orchards.

5.31 The second approach is to use the discounted value of future returns. For many environmental assets there are no relevant market transactions or set of acquisition prices that would permit the use of the previous two approaches. Thus, although prices can be found to value the output from extraction or harvest of an environmental asset, no values for the asset itself, *in situ*, are available. In this situation, the discounted value of future returns approach, commonly referred to as the Net Present Value approach – or NPV – uses projections of the future returns from the use (usually extraction or harvest) of the asset. Typically these projections are based on the history of returns earned from the use of the environmental asset. Assuming that returns earned in the current period are worth more to the extractor than returns earned in the future, the stream of expected returns is discounted to reflect the value a buyer would be prepared to pay for the asset in the current period.

5.32 In the valuation of ecosystems there is potential to consider the use of NPV approaches. The use of NPV may be appropriate to take into account the diverse set of ecosystem services which reflect both public and private services. The diverse set of services means that observed exchange values for an ecosystem encompassing the complete set of services are unlikely to be found. In some instances, valuations available on the market for certain tracts of land including agricultural land and forests, may provide some indications of value of the capacity to provide certain ecosystem service flows but an assessment of the value of an ecosystem must, in principle, cover all expected future flows of ecosystem services.

5.33 The SEEA Central Framework discusses NPV approaches at length in Chapter 5 in the context of individual environmental assets such as mineral and energy resources, timber resources and aquatic resources. The same general principles apply in the use of NPV approaches for ecosystem accounting purposes. The value of an ecosystem is, in theory, equal to the sum of the NPV of each ecosystem service and the value of an ecosystem obtained following this logic would be measured consistently with underlying SNA principles.

5.34 However, in the context of ecosystems the application of NPV approaches is a more complex task. For individual environmental assets there is usually an observed market price for the estimation of the resource rent which is a single income flow that must be projected and discounted to form an NPV estimate. For ecosystems, there is generally no single, identifiable income flow and thus it is necessary to consider the value of all relevant ecosystem services and how these services might be delivered in the future.

Boundaries of market price based valuation

5.35 The valuation approaches described in the SEEA, in particular the Net Present Value approach, provide reasonable proxies for observable market prices and consistency with the SNA, but do not take into account the full range of benefits (and costs) that might be considered relevant. For example, the value of a second-hand car in the market place will often be less than the value that the current owner places on the utility and flexibility of car ownership. At the same time, the car’s value to its owner may not reflect the impact of emissions from operating the car on the environment. Thus while the use of market prices allows comparison across asset types these prices may not reflect the value of the asset from an individual or societal perspective. This aspect of market based prices is often mentioned in relation to the valuation of environmental assets. This leads into the area of welfare accounting which is not the focus of the SEEA.

The decomposition of value into price, quantity and quality

5.36 The analysis of changes in value over time is an important aspect of accounting. Generally, the accounting structures consider changes in value by recording the different types of flows that may take place over an accounting period. Thus, for example, it is possible to determine whether changes in the total income of a household are due to changes in wages and salaries, receipts of interest, payments of taxes, or the receipt of social assistance benefits. Accounting structures ensure that the concepts of each of the elements of change are clearly defined.

5.37 An alternative way of considering changes in value is to recognise that changes may arise due to changes in prices or changes in quantity. Thus an enterprise's value of sales may increase either because the prices charged have increased or because quantities sold have gone up (or a combination of these factors). In some cases the accounting structures take this type of decomposition into account, specifically there is the recording of revaluations to explain the change between opening and closing values of assets. However, in many cases, such as the assessment of the reason for the enterprises increase in sales, there is no relevant accounting entry.

5.38 Thus for national accounting purposes, the decomposition of value into price and quantity components is undertaken with an index number framework. This framework also provides the basis for the direct measurement of price change (for example, the Consumer Price Index). Index number theory is well established but, at the same time, there are a number of choices that can be made in undertaking any decomposition of values.

5.39 The key issue from the perspective of ecosystem accounting is that the notion that values are simply composed of prices and quantities is an oversimplification that may work for the development of economic theory but does not work well for statistical measurement. The practical difficulty is that the items being valued will generally change in quality over time. For example, a new car purchased in 1990 is likely to be quite different in quality from one purchased in 2012 even allowing for general features such as engine size and number of seats. Thus simply tracking the purchase price of a car and using a quantity of one does not provide a good indication of the decomposition. A reasonable assessment must take into account the changes in quality.

5.40 The most dramatic example of this over the past 30 years has been the fairly stable price of computers that are of constantly increasing in speed and capacity. The rapid rise in quality must be considered and in fact, it turns out that there has been quite a dramatic fall in the price of computers when the increasing quality is taken into account.

5.41 For complex items, such as cars and computers, methods have developed to make assessments of the changes in quality on an ongoing basis. These approaches are known as hedonic approaches and rely on breaking up an item into its various "characteristics". Assessment of the change in each of the characteristics is then aggregated to form an overall assessment of whether the total value (i.e. purchase price) of an item is due to changes in quality.

5.42 Given the complexity of ecosystems, the application of similar types of methods to assess changes in overall value, may be appropriate. This would require the identification of the key characteristics of an ecosystem and the determination of methods of aggregating these characteristics and both of these steps are not straightforward. It is noted also that the distinction between quantity and quality is inherent in the model for assessing the capacity of ecosystems where capacity is a function of extent and condition. Overall, the importance of accounting for changes in quality in both ecosystem services and ecosystem capacity suggests that it would be possible to take advantage of the well-established techniques in economic statistics for distinguishing between price, quality and quantity.

5.3 Summary of approaches to valuing ecosystem services

5.3.1 Basic concepts

Monetary values

5.43 In neo-classical welfare economics, value is related to the price of the good or service in an open and competitive market, as a function of demand and supply. Accordingly, for traded ecosystem services, under perfect market conditions, market price reflects the marginal economic value of the service.

5.44 The total economic value related to the supply of an ecosystem service (or any other good) is the sum of the consumer and the producer surplus. The individual consumer surplus equals the willingness-to-pay of a consumer for a good minus the price the consumer faces for that good. The aggregate consumer surplus reflects the surpluses obtained by different consumers at a given market price. Consumer surplus is not included in SEEA and therefore there is a need to disentangle the consumer surplus from valuation estimates resulting from the application of certain valuation methods.

5.45 The producer surplus indicates the amount of net benefits a producer gains, given his production costs and the (market) price he receives for his products. In the valuation of ecosystem services, the producer surplus needs to be considered if there are costs related to “producing” the ecosystem good or service, which include both the costs related to maintaining the ecosystem and the costs related to the extraction or use of the service. In case an ecosystem services approach is used to analyse activities such as agriculture or fisheries, the full production costs of the fisherman (boat, equipment, labour, etc.) or farmer (land, machinery, inputs, labour, etc.) need to be accounted for.

5.46 There are several types of economic value that can be attributed to ecosystem services. In general, the following four types of value can be distinguished: (i) direct use value; (ii) indirect use value; (iii) option value; and (iv) non-use value.

5.47 (i) Direct use value arises from the direct utilisation of ecosystems, for example through the sale or consumption of a piece of fruit. All provisioning services, and some cultural services (such as recreation) have direct use value.

5.48 (ii) Indirect use value stems from the indirect utilization of ecosystems, in particular through the positive externalities that ecosystems provide. This reflects the type of benefits that regulating services provide to society.

5.49 (iii) Option value relates to risk. Because people are unsure about their future demand for a service, they are willing to pay to keep the option of using a resource in the future – insofar as they are, to some extent, risk averse. Option values may be attributed to all services supplied by an ecosystem.

5.50 (iv) Non-use value is derived from attributes inherent to the ecosystem itself. Three aspects of non-use value are generally distinguished: existence value (based on utility derived from knowing that something exists), altruistic value (based on utility derived from knowing that somebody else benefits) and bequest value (based on utility gained from future improvements in the well-being of one's descendants). The different categories of non-use value are often difficult to separate, both conceptually and empirically.

5.51 In principle, the four value types: direct use, indirect use, option and non-use value are exclusive and may be added. The sum of the direct use, indirect use and option values equals the total use value of the system; the sum of the use value and the non-use value has been labelled the 'total economic value' of the ecosystem. If all values have been expressed as a monetary value, and if the values are expressed through commensurable indicators, the values can be summed. In practice, however, few valuation studies have valued option values of ecosystem services, and there is still considerable debate on the quantification of non-use flows.

Ecosystem services as public or private goods

5.52 Provisioning services are typically private goods whereas many regulating and cultural services have a public goods character. Public goods involve the conditions of (i) non-excludability, meaning that is not possible to deny people to benefit from the ecosystem service and (ii) non-rivalry, meaning that one person's enjoyment of an ecosystem service does not diminish the availability of the service to others. Clean air or biodiversity are typical examples of public goods. Eco-tourism can be seen as a 'quasi' public good, to a degree it is non-rivalrous, but in principle it is excludable (e.g. by placing a fence around an ecosystem and charging entrance fees). The price mechanism for the provision of public goods does not function well: consumers do not have an incentive to pay and producers do not have an incentive to supply. Consequently, public intervention is needed to maintain or create an efficient allocation of such goods. Because public goods are not traded in a market, such goods require the application of non-market valuation methods.

5.3.2 General approaches to the valuation of ecosystem services in monetary terms

Defining the scope and objects of valuation

5.53 In estimating values for ecosystem services in monetary terms (often by translating physical flows into monetary values using prices), it is critically important to be specific about both the scope and object of valuation. The scope of the valuation in the case of ecosystem accounting needs to be aligned to valuation principles of the SNA (and the SEEA). This means valuation should be based on, in decreasing order of preference: observed market prices, revealed market prices or stated preference studies. Consumer surpluses are not part of SNA valuations and should be excluded.

5.54 The initial objects of valuation in ecosystem accounting are the provisioning, regulating and cultural services provided by ecosystems. Supporting services, as identified in the Millennium Assessment can be defined as ecological processes that support the generation of other services and should therefore not be valued separately. Ecosystem services constitute flows from the ecosystem to the economy, and can be measured in terms of a quantity of physical or monetary units supplied per year. Aggregation over a specific time period, and discounting of future flows of services is required to define a net present value of an ecosystem. The aggregation of values of ecosystem services is not discussed in this section.

5.55 A general caveat is that economic valuation approaches tend to adopt a partial equilibrium framework, so that even when they reflect directly or indirectly consumers' budget constraints the broader impact on other markets and hence demand and supply of other goods and services is not tracked.

Monetary valuation of provisioning services

5.56 Provisioning services comprise, jointly with labour and produced capital, an input into the production process and are remunerated in the gross operating surplus generated. The gross operating surplus is that part of value added that remains after deducting the compensation of employees and the other taxes less subsidies on production. This operating surplus can be partitioned to show how much is due to produced assets and how much to natural assets. The part due to natural assets is the resource rent. The other part is called 'the user costs of produced capital'. (This partitioning is described in greater detail in SEEA Central Framework Section 5.4)

5.57 Resource rent is present in sectors that are able to harvest a yield from ecosystems. Under certain conditions, the resource rent can result in additional revenue beyond the normal compensation for labour, capital and other production factors.

5.58 However, a number of market conditions must be in place for estimates of resource rent to accurately reflect a price for the ecosystem services that takes into account the potential for degradation of the resource. These conditions include that the resource is being extracted / harvested in a sustainable way, that there is ownership of the underlying resource, and that the owner seeks to maximise their resource rent. Consistent with these observations it is noted that if new producers can easily enter and extract or harvest resources then it would be expected that these resource users will increase investment and production up to the point where the returns on produced assets in the activity will be equal to those in other, non-resource extracting activities.

5.59 Where these conditions are not met the resource rent is likely to understate the "true" price of the resource since any degradation of the resource will not be factored into the price required by the extractor to cover their extraction costs.

5.60 Assuming that appropriate operating conditions exist, the flows of provisioning services can be valued in monetary terms by analysing the resource rent they generate. The resource rent generated by the ecosystem needs to be distinguished vis-à-vis the user costs of produced capital on the basis of establishing and deducting an appropriate return on other capital inputs. In general, it can be assumed that the resource rent will comprise a major part of the total economic rent in situations where the ecosystem services cannot be provided through the use of produced capital (and associated labour and other inputs), and where they comprise a limiting constraint on production possibilities.

5.61 To a degree, the value of present and future flows of provisioning services is reflected in the value of land on which these services are produced. This is most obvious in the case of agricultural land, where per hectare land prices reflect the possibilities to grow crops as a function of soil type, water availability, soil nutrient retention capacity, availability of pollinators, etc. If agricultural land is bought and sold with the single aim of agricultural production, the land price reflects the ecosystem's capacity to support agricultural production. Market transactions presumably account for the potential revenue that can be generated on that land given potential productivity, crop prices, prices of other inputs, etc. In general, land prices can be expected to reflect the capacity to generate market and non-market ecosystem services that accrue to the land owner. Using this information the annual rent payable on agricultural land should provide a basis from which to derive estimates of the value of the flow of ecosystem services over an accounting period.

5.62 For the provisioning services 'agricultural production' and 'aquaculture', the products resulting from the combination of the ecosystem inputs and other capital factors are traded in the market, but the flow of ecosystem services itself (i.e. the aggregate flow of nutrient, energy and water from the ecosystem to the harvestable crop) is not – even though the price of agricultural land reflects the potential to provide this service over time as discussed above. For these services, the resource rent may be used as proxy of the monetary value generated by the provisioning service. Cross-checking with land prices and associated payments of rent (or imputed rent) provides a potential method of verifying the value estimate for the ecosystem service.

5.63 For other provisioning services, such as for instance timber production, resource rents also represent a proxy for the upper bound of the monetary value generated by the ecosystem service. However, if the ecosystem service itself is traded in a market, a more direct valuation approach is possible. For instance, in the case of timber, both harvested timber and standing stocks of timber may be traded and priced in a market. In addition, there are often prices paid for trees just prior to harvesting (known as stumpage prices). The valuation of the ecosystem services in this situation may be derived following the methods outlined in SEEA Central Framework Section 5.8.

5.64 A sub-set of the provisioning services is not traded in a market, for instance because the goods involved are used for home consumption (e.g. timber collected for heating, crops grown for own-consumption). For these provisioning services surrogate prices should be established, for instance on the basis of the same goods traded on the market. Valuation approaches for such goods have been developed in the context of the SNA and are discussed in more detail in the material concerning valuation approaches in the SNA.

Monetary valuation of regulating services

5.65 There is increasing experience with establishing markets for regulating services, in particular for carbon sequestration, but to a smaller degree also for hydrological services, in particular the control of sedimentation. For carbon, there are a range of different markets operating in different parts of the world and with a different degree of maturity and market turn-over. The largest market is the European Carbon Trading Scheme, but this market does not include carbon sequestration in ecosystems. Indeed it is important to distinguish between markets that relate to the limited right to emit pollution and markets in ecosystem services themselves.

5.66 Carbon sequestered in ecosystems is mainly traded in the voluntary carbon market. Carbon markets are rapidly evolving. A new market scheme in New Zealand permits the trading of credits from forest carbon in a compliance scheme, but so far only small quantities of forest carbon have been traded. In compliance markets, the price of carbon is strongly influenced by the regulatory setting of the market, and prices have fluctuated rapidly in response to changes in these settings. Prices in the voluntary market have fluctuated less, typically being in the order of US$ 5 / ton CO_2. Note that, in the case of carbon sequestration and storage, carbon (C) and carbon dioxide (CO_2) can be converted at the rate of 1 ton of C equalling 3.67 ton of CO_2.

5.67 To date, most market transactions on forest carbon concern the sequestering rather than the storage of carbon in ecosystems. Recently, however, a number of pilot projects in the domain of REDD (Reduced Emissions from Deforestation and Degradation) have been started. These projects sell carbon credits from reduced carbon emissions to the atmosphere generated by activities aiming to reduce deforestation and/or degradation, hence to maintain the storage of carbon in an ecosystem. Payments are made, in the case of REDD, for reducing emissions compared to a baseline case representing business as usual emission rates, i.e. with no REDD project in place. The market for both the sequestration and storage of carbon in ecosystems is reflected in the way carbon services are defined for SEEA Experimental Ecosystem Accounts (draft Chapter 3). In order to establish a price for carbon, a first estimate can be based on the price raised in voluntary markets. Potentially, when compliance carbon markets mature and further allow the inclusion of carbon storage and/or sequestration in ecosystems, new (generally higher) prices raised in these markets can be used to value carbon.

5.68 For the other regulating services, there are generally no market prices available, and alternative approaches have to be followed to obtain an indication of the marginal value of these services. In the environmental economics literature, a broad range of non-market valuation techniques has been developed. A brief description of the methods most relevant in the context of ecosystem accounting is provided below.

5.69 <u>Production function approaches.</u> Production function approaches estimate the contribution of ecosystem services to production processes in terms of their contribution to the value of the final product being traded on the market. The general principle, i.e. disentangling the contribution from the ecosystem versus contributions from other production factors, is analogous to the use of the resource rent as a proxy for the monetary value of provisioning services. Production function approaches are also used to value indirect use values generated by regulating services such as the storm and flood protection service, by disentangling their contribution to the generation of outputs traded in a market.

5.70 Hedonic pricing method. Hedonic methods analyse how environmental quality affects the price people pay for a good or factor. Hedonic pricing can be applied to reveal the value of local ecosystem services that contribute to the value of a property, as in the case of urban greenspace increasing local house prices. In this case, hedonic pricing involves decomposing sale prices of houses into implicit prices for the properties of the house (e.g. number of rooms, size of the lot, etc.), other factors, and local ecosystem services. The application of a hedonic analysis requires data on a large number of property sales where characteristics of the properties including the availability of ecosystem services vary.

5.71 Replacement cost method. This method uses the cost of replacing an ecosystem service as an indication of the monetary value of an ecosystem service. The application of the replacement cost method in environmental economics has been disputed because it does not express preferences. The method is somewhat more suitable in the context of ecosystem accounting that by definition excludes the consumer surplus. In general, there are three preconditions for the use of this method: (i) the alternative considered provides the same services; (ii) the alternative used for cost comparison is the least-cost alternative; and (iii) it should be reasonable to assume that an alternative for the ecosystem service would be demanded by society if it were provided by that least-cost alternative. This method is of particular relevance for the flood protection service, in the cases where it can plausibly be assumed that alternative flood protection measures would have to be taken in absence of an ecosystem (e.g. dunes, mangroves, coral reef) providing the flood protection service.

5.72 Averting behaviour methods. Averting behaviour methods are used as an indirect method to evaluate the willingness of individuals to pay for improved health or to avoid undesirable health consequences. Averting behaviour models are based on the presumption that people will change their behaviour and/or invest money to avoid an undesirable outcome resulting from ecosystem degradation. The incurred expenditures provide an indication of the monetary value of the perceived change in environmental conditions. Contrary to the replacement cost valuation method, the averting behaviour method is based on individual preferences. For example, in the presence of water pollution, a household may install a filter on the primary tap in the house to remove or reduce the pollutant. It is necessary for households to be fully aware of the impacts on them resulting from environmental changes in order for this method to be applicable.

Monetary valuation of cultural services

5.73 For tourism and recreation, and biodiversity conservation, a different valuation approach is needed. Generally tourism is valued with the travel cost method, but this method results in the measurement of the consumer surplus generated for visitors to ecosystems and is not relevant in the context of SEEA. Analysing the benefits accruing to visitors of ecosystems in a manner consistent with SNA is not straightforward, potentially this can be done by analysing entrance fees. For ecosystems where no entrance fees are collected, potentially there is scope to estimate surrogate entrance fees by comparing ecosystems to comparable areas where such fees are charged.

5.74 In terms of analysing benefits accruing to the recreational sector, a challenge is to disentangle the contribution of the ecosystem to the overall recreational experience, potentially with a production factor approach. For the valuation of biodiversity conservation, which generates non-use value, stated preference methods are most commonly applied. Recently, several market schemes for biodiversity have been developed, which enhances valuation possibilities for biodiversity, as discussed below.

5.75 *Stated preference methods*. The most important approaches are the Contingent Valuation Method (CVM) and related methods (including choice experiments and conjoint analysis). Contingent valuation studies typically ask respondents to state a value they attribute to a certain ecosystem, ecosystem property or ecosystem service. Choice experiments ask respondents to compare an ecosystem, ecosystem property or service with a marketed good or service, and in conjoint analysis, survey respondents are typically given alternatives to consider (e.g. three management options with different implications for ecosystem services supply). For each of the stated preference methods, the set-up of the questionnaire is critical; respondents need to be presented a credible case for a potential payment for an ecosystem service. Econometric procedures reveal monetary values on the basis of choices or ranks.

5.76 The main advantage of stated preference methods is that, unlike other valuation methods, they can be used to quantify the non-use values of an ecosystem in monetary terms. There are two main points of criticism against CVM and related methods. First, CVM estimates are sensitive to the order in which goods are valued; the sum of the values obtained for the individual components of an ecosystem is often much higher than the stated willingness-to-pay for the ecosystem as a whole. Second, CVM often appears to overestimate economic values because respondents do not actually have to pay the amount they say they would be willing to pay for a service. Hence, monetary value estimates obtained with CVM and related methods need to be treated with some caution. In addition, these methods measure preference and are therefore not necessarily aligned with the SNA valuation principles.

5.3.3 Recent developments in ecosystem services valuation

5.77 <u>The Simulated Exchange Value approach.</u> The Simulated Exchange Value approach is an alternative approach to welfare based valuation which has been proposed by a team of Spanish economists in the specific context of green accounting in the forestry sector. The approach aims to measure the income that would occur in a hypothetical market where ecosystem services were bought and sold. It involves estimating a demand and a supply curve for the ecosystem service in question and then making further assumptions on the price that would be charged by a profit-maximising resource manager under alternative market scenarios. It then takes the hypothetical revenue associated to this transaction (but not the associated consumer surplus) as a measure of value of the flow of ecosystem services (see Figure 1).

5.78 The Simulate Exchange Value approach estimates the value of ecosystem services in terms of potential revenue and can therefore arguably represent a more consistent basis for including their value in national accounts alongside monetary transactions. A caveat is that economic valuation studies tend to adopt a partial equilibrium framework, so that even when they reflect directly or indirectly consumers' budget constraints the impacts on other markets is not being tracked, so some consistency issue also applies to Simulated Exchange Value approaches.

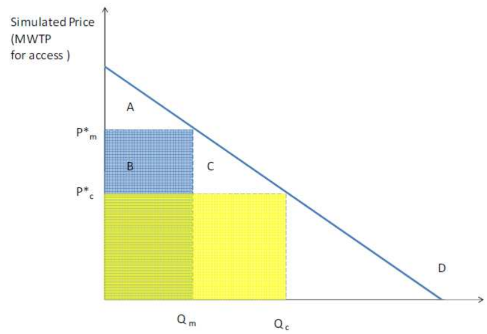

Figure 1 The Simulated Market Price Approach uses demand and supply curve information for the ecosystem service in question to estimate a hypothetical monopoly price (P*m) and competition price (P*c). It then estimates the associated revenue under the demand curve by multiplying these prices for the associated, hypothetical quantities. What the approach does not do is to include in these calculations consumer surplus (areas A under monopoly or A+B+C under competition in the picture).

5.79 New markets for biodiversity and other ecosystem services. Biodiversity is a public good providing a non-use value. It's definition is broad, and not necessarily well-aligned with society's preferences given that people tend to place different values on different species. It is therefore notoriously difficult to attribute a monetary value to this ecosystem service, with stated preference methods. However, several recent developments involving the establishment of markets for biodiversity provide an entry point for a better understanding of the monetary value of the service.

5.80 Market-conforming biodiversity mitigation mechanisms include mitigation banking of biodiversity credits, programs that channel development impact fees and offset policies. A limited number of biodiversity markets have been set up that fulfil the basic characteristics of a market: (i) the presence of buyers and sellers; (ii) a traded unit, reflecting biodiversity; (iii) a market clearing mechanism in which a price is established; and (iv) an institutional setting regulating the market and ensuring compliance. The traded unit in these markets are commonly credits related to species or to acreage of habitat conserved.

5.81 Examples of emerging biodiversity markets are (i) Conservation Auctions in Victoria, Australia; (ii) BioBanking, New South Wales, Australia; (iii) Conservation banking (US); and (iv) Wetland and Stream Mitigation Banking (US). The oldest of these schemes is the Wetland and Stream mitigation banking scheme, with total annual wetland and stream payments reported to be in the order of U$1.5 billion for 2008. These schemes allow establishing a surrogate market price for the biodiversity units traded in such markets, but in needs to be kept in mind that the price of the units strongly depend on the local ecological and institutional setting and that it cannot easily be translated to the value of biodiversity in other places.

5.3.4 Issues in valuation measurement

Benefit transfer

5.82 Benefit transfer involves taking an existing value estimate and transferring it to a new application that is different from the original one. There are two types of approaches to benefit transfer, respectively value transfers and function transfers. A value transfer takes a single estimate of the value of an ecosystem services, or an average of several value estimates from different studies, to estimate the value of an ecosystem service in a different context. A function transfers uses an estimated equation to predict the value of an ecosystem service in a new setting, correcting for different environmental factors on the basis of a regression model.

5.83 The values provided by ecosystem services are often strongly dependent on the biophysical, economic and institutional context, which makes it difficult to assume that value estimates of specific services apply also in a different context. In addition, there is still relatively scarcity of data on the monetary value of ecosystem services, and different valuation studies may be based on different assumptions and using different methodological constructs. Hence, benefit transfer is prone to a high degrees of uncertainty, in particular if done poorly.

Uncertainty in valuation

5.84 There are significant sources of uncertainty in ecosystem accounting. These can be grouped in four main categories: (i) uncertainty related to physical measurement of ecosystem services and ecosystem capital; (ii) uncertainty in the valuation of ecosystem services and capital; (iii) uncertainty related to the dynamics of ecosystems and changes in flows of ecosystem services; and (iv) uncertainty regarding future prices and values of ecosystem services.

(i) uncertainty related to physical measurement of ecosystem services and ecosystem capital. It is clear that, given data scarcity for many ecosystem services, physical measurement of the flow of ecosystem services, in particular at aggregated levels, is prone to uncertainty. Most countries do not consistently measure flows of ecosystem services at an aggregated (national or even sub-national) scale, and services flows need to be estimated on the basis of point based observations in combination with spatial data layers and non-spatial statistics. At the same time, it is noted that information related to flows of provisioning services are generally, readily available.

(ii) uncertainty in the valuation of ecosystem services and ecosystem capital. A second source of uncertainty relates to the monetary value of ecosystem services. For provisioning services, a key aspect is that attributing a resource rent to ecosystems involves a number of assumptions regarding rent generated by other factors of production. For non-market ecosystem services, it is often difficult to establish both the demand for these services and to reveal the supply of these services by ecosystems, in particular at an aggregated scale.

(iii) uncertainty related to the dynamics of ecosystems and changes in flows of ecosystem services. Establishing the value of ecosystem capital requires making assumptions regarding the supply of ecosystem services over time, which in turn depends on the dynamics of the ecosystem. Changes in ecosystem capital will often be reflected in a changed capacity to supply ecosystem services. In the last two decades, it has become clear that ecosystem changes are often sudden, involving thresholds at which rapid and sometimes irreversible changes to a new ecosystem state occur. Predicting the threshold level at which such changes occur is complex and prone to substantial uncertainty.

(iv) uncertainty regarding future prices and values of ecosystem services. Pricing benefits and costs that may accrue in the far-distant future is complex because it is extremely difficult to predict our circumstances in the future. The ecological implications of humanity's continuing modification of the climate and landscape are uncertain, and those implications are likely both to affect and to depend on how the future evolves. Uncertainties concerning values are even greater inasmuch as the methods of nonmarket valuation compound errors in estimation.

5.85 The best strategy to deal with the sources of uncertainty will vary per country as a function of data availability and relevant services selected for ecosystem accounting. Given the limited experience to date with analysing ecosystem services in both physical and monetary terms at the national level the approaches to limiting these uncertainties and maximise the robustness of ecosystem accounting will need to be further developed once more practical experience with ecosystem accounting has been gathered and evaluated. The experiences gathered with national level assessment of ecosystem services supply are also highly relevant in this context.[1]

5.3.5 Conclusions on valuation in ecosystem accounting

To be drafted

5.4 Examples of valuation for selected ecosystem services

To be drafted

[1] See for example the UK National Ecosystem Assessment (2010)

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SEEA Experimental Ecosystem Accounts

Accounting for ecosystems in monetary terms:

Annotated outline of Chapter 6 SEEA Experimental Ecosystem Accounts

(for discussion)

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

SEEA Experimental Ecosystem Accounts

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DRAFT

Accounting for ecosystems in monetary terms:

Annotated outline of Chapter 6 SEEA Experimental Ecosystem Accounts

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 6

The drafting of the SEEA Experimental Ecosystem Accounts commenced in April 2012 and has focused on drafting material to describe the context and purpose for ecosystem accounting (Chapter 1), the general accounting and measurement model for ecosystems and ecosystem services (Chapter 2), the definition and measurement of ecosystem services (Chapter 3), and the measurement of ecosystem capital (Chapter 4), and valuation approaches for ecosystem accounting (Chapter 5). Draft material on all of these chapters (except for Chapter 1) was completed for consideration by the Expert Group on Ecosystem Accounts at their meeting in Melbourne in May 2012.

At this stage material on Chapter 6 covering accounting for ecosystems in monetary terms has not been drafted. The following material provides an overview of the anticipated content such that discussion on this issue may proceed. It is noted that the final content of Chapter 6 will, in part, depend on decisions taken with respect to the valuation of ecosystem capital and ecosystem services.

Although draft material has not yet been prepared, there have been a number of ongoing discussions on the appropriate accounting for ecosystems in monetary terms. These discussions have focused on the appropriate incorporation of measures of stocks and flows of ecosystem capital and ecosystem services into the sequence of economic accounts and balance sheets of the SNA. A number of accounting models have been proposed but further discussion is required, especially within the national accounts community. This discussion will be co-ordinated by the SEEA Editor.

Annotated outline

Section 6.1: Uses of estimates in monetary terms

This section will explain the rationale for compiling aggregate estimates of ecosystem capital and ecosystem services in monetary terms highlighting potential accounting applications such as the measurement of consumption of ecosystem capital (CEC) adjusted aggregates (e.g. CEC adjusted GDP), and the development of wealth accounts. The potential to use valuations of ecosystem capital and ecosystem services to assess the relative merits of expenditure on ecosystem maintenance and restoration will also be discussed.

Section 6.2: Integration of ecosystem accounts and economic accounts in monetary terms

This section aims to explain three areas related to the integration of ecosystem accounts: (i) the compilation of a sequence of economic accounts taking into account ecosystem services and other ecosystem flows, especially consumption of ecosystem capital; (ii) the derivation of aggregate measures of economic activity, such as GDP and Net National Income, that are adjusted for consumption of ecosystem capital; and (iii) the compilation of wealth accounts that compare the values of ecosystems with values of produced assets, financial assets (and liabilities), and other economic assets in an extended balance sheet.

(i) Sequence of accounts. The description of a sequence of accounts builds on the sequence of accounts presented in the SEEA Central Framework (see table below). The aim is to show the series of additional entries that are required in the standard SNA sequence of accounts such that measures of consumption of ecosystem capital can be associated with relevant measures of income and such that expenditures to maintain and restore ecosystems can be appropriately reflected in the set of accounts. The sequence of accounts will also need to incorporate accounting for changes in ecosystems that are due to natural causes.

There are two main issues to consider in developing a sequence of accounts that takes ecosystems into account. The first concerns the appropriate recording of the non-material benefits from ecosystem services that are not within the SNA production boundary. Expanding the SNA production boundary for the purposes of integrating flows related to ecosystems has a range of implications that need to be discussed and evaluated.

Second, when developing a sequence of accounts for institutional sectors in the economy (i.e. corporations, households, government), the issue arises as to whether ecosystems should be considered an asset within the overall balance sheet of an institutional unit or whether ecosystems should be considered as constituting their own (quasi) institutional sector (and hence an additional column must be introduced in the sequence of accounts) with a series of flows recorded between ecosystems and the other sectors. Again there is a range of implications for the accounts of going down either path that need to be discussed and evaluated.

Overall, it remains an open question as to whether a single structure for a sequence of accounts should be recommended or whether both might be discussed, and further, if a choice is made, which structure should be preferred. It is noted that the choice of structure for a sequence of accounts does not invalidate any of the information compiled on ecosystem services or ecosystem capital as described in earlier chapters.

(ii) Consumption of ecosystem services adjusted aggregates. The discussion here is to present some of the main aggregates that might be compiled using a sequence of accounts in monetary terms. This discussion would be related to the measurement of depletion adjusted aggregates which is described in the SEEA Central Framework Chapter 6.

(iii) Compilation of wealth accounts. Wealth accounting and the inclusion of measures of natural capital within a broad national balance sheet has been a focus for many involved in the valuation of ecosystems. This text will discuss how such accounts might be compiled and presented and consider issues of interpretation particularly as regards assumptions concerning sustainability.

Although the compilation of wealth accounts may seem as simple as adding the value of ecosystems to the value of produced and other economic assets, in practice careful delineation of the boundaries of valuation will be needed since many economic assets, particularly land, are also within the scope of the valuation of ecosystem, albeit that they are valued from a different perspective. For example, the value of an area of land will include an amount relevant to the location value of the land but this aspect of the value of land (the value of its space provisioning service) is not considered part of ecosystem services and hence is not part of the value of ecosystem capital. Also, some natural resources are not part of ecosystem values (e.g. mineral and energy resources) and the boundaries around the inclusion of cultivated biological resources will need to be clarified.

Section 6.3 Treatment of taxes, subsidies and other transactions related to the environment

An important area of environmental accounting is appropriately recording standard economic transactions that are considered environmental. In this context, the SEEA Central Framework Chapter 4 describes at some length the compilation of Environmental Protection Expenditure Accounts (EPEA) and Environmental Goods and Services Sector (EGSS) statistics, and also defines environmental taxes and subsidies.

In the context of ecosystem accounting it is relevant to consider the appropriate accounting for economic transactions related to ecosystems. This text will build on the discussion of the accounting issues in the SEEA Central Framework (Chapter 4) but will extend to consider the appropriate recording of transactions associated with purchases of ecosystem services by governments and the development of markets in ecosystem services. The recording described will be consistent with standard treatments in the SNA and will use the structure of the sequence of accounts as a basis for the description.

It is not proposed to discuss the development of functional accounts (e.g. EPEA) for ecosystem accounting aside from relevant references to Chapter 4 in the SEEA Central Framework. The Classification of Environmental Activities, in particular Part I on Environmental Protection, covers all activities related to the restoration and conservation of ecosystems. While more targeted functional accounts that target these specific activities might be developed (rather than EPEA which have a broader coverage), the same measurement techniques and considerations apply and do not require further elaboration in SEEA Experimental Ecosystem Accounts.

While specific functional accounts will not be discussed, it is relevant to consider ways in which data may be drawn together from the broader ecosystem accounting framework to assess the effectiveness of expenditure on environmental protection and resource management in terms of ecosystem capital and ecosystem services.

Table 6.2.3 SEEA Central Framework sequence of economic accounts

Accounting entry	Institutional sectors				Total Economy
	Corporations	General government	Households	NPISH*	
Production account					
Output	2954	348	270	32	3604
Taxes less subsidies on products	na	na	na	na	133
Less Intermediate consumption	1529	222	115	17	1883
*Gross Value Added**	1425	126	155	15	1854
Less Consumption of fixed capital	169	27	23	3	222
Net Value Added	1256	99	132	12	1632
Less Depletion of natural resources	6	0	0	0	6
Depletion adjusted Net Value Added	1250	99	132	12	1626
Generation of income account					
Gross value added	1425	126	155	15	1854
Less Compensation of employees payable	1030	98	11	11	1150
Less Other taxes less subsidies on production	57	1	-1	1	58
Less Taxes less subsidies on products	na	na	na	na	133
Gross operating surplus	338	27	145	3	513
Less Consumption of fixed capital	169	27	23	3	222
Less Depletion of natural resources	6	0	0	0	6
Depletion adjusted Net Operating surplus	163	0	122	0	285
Allocation of primary income account					
Depletion adjusted Net Operating surplus	163	0	122	0	285
Plus Compensation of employees receivable (Households only)			1154		1154
Plus Taxes less subsidies on production receivable (General government only)		191			191
Plus Property income receivable (interest, dividends, rent)	245	22	123	7	397
Less Property income payable	302	42	41	6	391
Depletion adjusted balance of primary income	106	171	1358	1	1636
Distribution of secondary income account					
Depletion adjusted balance of primary income	106	171	1358	1	1636
Plus Current transfers receivable	347	367	420	40	1174
Less Current Transfers payable	375	248	582	7	1212
Depletion adjusted Net Disposable Income	78	290	1196	34	1598
Use of disposable income account					
Depletion adjusted Net Disposable Income	78	290	1196	34	1598
Less Final consumption expenditure	0	352	1015	32	1399
Depletion adjusted Net Saving	78	-62	181	2	199
Capital account					
Depletion adjusted Net Saving	78	-62	181	2	199
Less Gross fixed capital formation	288	35	48	5	376
Less Changes in inventories	26	0	2	0	28
Less Acquisitions less disposals of valuables	2	3	5	0	10
Less Acquisition less disposals of natural resources and land	-7	2	4	1	0
Less Acquisition less disposals of other non-produced, non financial assets					
Plus Capital transfers receivable	33	6	23	0	62
Less Capital transfers payable	23	34	5	3	65
Add back Consumption of fixed capital	169	27	23	3	222
Add back Depletion of natural resources	6	0	0	0	6
Net Lending/Borrowing	-46	-103	163	-4	10

* Non-Profit Institutions Serving Households

** GDP equals the gross value added for all institutional sectors plus taxes less subsidies on products.