European Environment Agency

Developing an EU Ecosystem Accounting System
Focus on marine ecosystems

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Room TS12A, Tour Séquoïa - 92055 La Défense cedex – France

Organisers: European Environment Agency and French Ministry for the Environment

Background material

1) Introduction - objectives of the workshop:

- Provide input to the planned EU integrated ecosystem accounting system
- Presentation of global and EU framework for ecosystem accounting
- Review current work on ecosystem accounts and ecosystem services for marine systems
- Identify user needs and objectives for marine part of EU ecosystem accounting system
- Develop recommendations on research and data investment for integrating marine systems into an EU ecosystem accounting approach

This workshop serves as a rapid assessment of options for marine ecosystem accounting and the knowledge required to implement them. The workshop outcome will support the integration of Europe's marine ecosystems into a proposal for the design of the future EU ecosystem accounting system that is to be developed under an EU knowledge innovation project ('KIP') on 'Accounting for natural capital and ecosystem services' (the 'KIP INCA' project).

The 'KIP INCA' project is one of the key collaborative projects between DG ENV, Eurostat, JRC, DGs RTD and CLIMA and the EEA at EU level. It has been put together to help develop the knowledge base for monitoring priority objective 1 of the 7th Environmental Action Programme of the EU (on preserving, conserving and enhancing natural capital). By the summer this projects needs to develop a concrete technical proposal on the future EU ecosystem accounting system for review and approval by EU Directors General and the EEA executive director.

The workshop plays a central role in tackling that task for marine systems and focuses on the biophysical dimension of ecosystem accounting. This follows the work flow adopted in the KIP INCA project (and recommended by global guidance) and is meant to help achieve very concrete outcomes. The valuation of ecosystems and their services is nevertheless an important part of the EU policy goals related to natural capital and will be tackled in the overall KIP INCA process. Hence the design and data foundation for developing physical marine ecosystem accounts for ecosystem assets and ecosystem service flows will be the main focus for this workshop.

2) Key questions to be addressed:

a) Understanding marine systems:

1. What are the special characteristics of marine ecosystems (in comparison to terrestrial ones)? As example: Is it important to take account of the three-dimensional nature of marine systems in developing marine ecosystem accounts?

2. What are the key marine ecosystem stocks (i.e. the bio-physical asset base that delivers services)?

3. Which types of ecosystem services derive from these stocks and how to measure them?

4. At what spatial resolution do we want to capture changes in marine ecosystem stocks and services?

5. Are there key policy questions and policy frameworks that we need to consider in developing marine ecosystem accounts?

b) Developing marine ecosystem accounts:

6. How to develop accounts for marine ecosystem stocks? If feasible – what are the key accounts?

7. How to develop accounts for marine ecosystem services? If feasible – which services to include?

8. What are the data needs for marine ecosystem asset accounts? (ecosystem 'extent and condition')? Can all assets be measured through primary data?

9. What are the data needs for marine ecosystem service accounts? Can all services be measured through primary data?

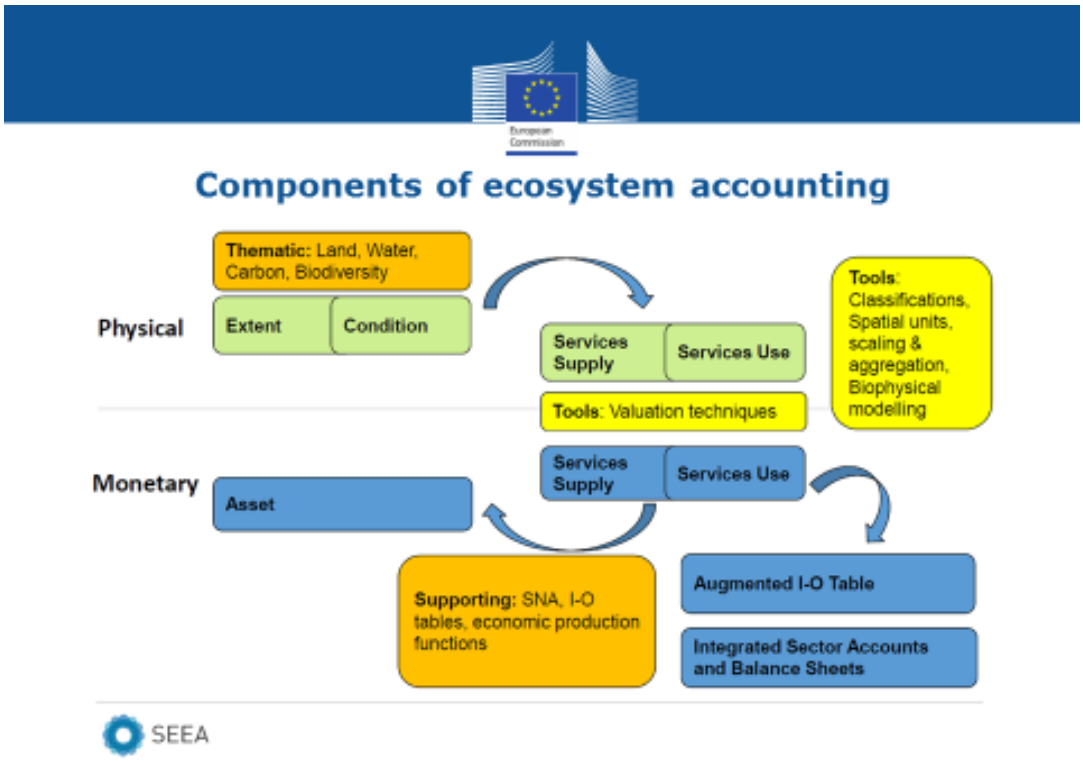
10. Which data collection and monitoring systems are required to develop a good knowledge base for marine ecosystem asset accounts and marine ecosystem service accounts?

11. What about the use of modelled (non-primary) data, including but not limited to data from bio-physical modelling? What are the characteristics of this modelled data and what role can it play in marine ecosystem asset and/or service accounts?

3) Selected material on the methodological approach of ecosystem accounting

The following section contains a few figures to illustrate key concepts in ecosystem accounting. This provides some essentials only. For further methodological insight please consult section 4 below or go to the global handbook on Experimental Ecosystem Accounting under the UNSD webpage on the System of Environmental-Economic Accounting (SEEA):
http://unstats.un.org/unsd/envaccounting/seeaRev/eea_final_en.pdf

The figure below shows the key components of an ecosystem accounting system as described in the SEEA experimental ecosystem accounting handbook published by the European Commission, the OECD, FAO, World Bank and the UN in 2014. The physical core accounts are in green: accounts for ecosystem extent, condition, ecosystem service supply and ecosystem service use. There are thematic accounts that describe water or carbon. And there are monetary accounts, shown in blue. The latter depend on reliable methods for valuation which is a major challenge and are a satellite extension to the standard national accounts.



The table below shows individual accounts for both assets and flows that have been proposed in the global environmental accounting guidance in SEEA-CF and SEEA-EEA (developed by the UN Statistical Division with country and expert support).

<table>
<tr><th colspan="2">SEEA Central Framework
(SEEA-CF)</th><th colspan="2">SEEA experimental ecosystem accounts
(SEEA-EEA)</th></tr>
<tr><th>Assets</th><th>Flows</th><th>Assets</th><th>Flows</th></tr>
<tr>
<td>In principle both physical and monetary accounts for:
• Mineral and energy resources
• Land
• Soil resources
• Timber resources
• Water resources
• Other biological resources</td>
<td>In principle both physical and monetary accounts for:
• Energy
• Water
• Material flows
• Air emissions
• Waste water
• Solid waste

Monetary accounts for:
• Environmental protection expenditure
• Environmental goods and services sector
• Environmental taxes and environmental subsidies</td>
<td>In principle both physical and monetary accounts for:
• Land accounts
• Carbon accounts
• Water accounts
• Soil and nutrient accounts
• Accounts for different types of ecosystems
• Biodiversity accounts</td>
<td>In principle both physical and monetary accounts for:
• Provisioning ecosystem services
• Regulation and maintenance ecosystem services
• Cultural ecosystem services</td>
</tr>
</table>

The table below provides an example for asset account and shows the types of annual changes that are meant to be recorded in an accounting table.

Basic form of an asset account
Opening stock of environmental assets
Additions to stock
Growth in stock
Discoveries of new stock
Upward reappraisals
Reclassifications
Total additions of stock
Reductions of stock
Extractions
Normal loss of stock
Catastrophic losses
Downward reappraisals
Reclassifications
Total reductions in stock
Revaluation of the stock
Closing stock of environmental assets

4) Extracts from a draft EU document on natural capital accounting:

The subsequent pages contain an extract of material from a draft EU reference document on natural capital accounting. The full draft document can be accessed at: http://projects.eionet.europa.eu/ecosystem-capital-accounting/library/reference-document-natural-capital-accounting

Executive Summary

Purpose of this document

The main purpose of this document is to support EU Member States in developing their own natural capital accounting approaches. As it is developed in the context of a European process for the implementation of the EU Biodiversity Strategy to 2020 it focuses on developing accounts for ecosystems and their services.

The document builds on a review of existing methodological guidance and puts forward a draft roadmap for the further development of natural capital accounting in the European Union. As a reference document it sets out basic concepts and approaches of natural capital accounting, provides methodological synthesis, practical advice and compiles key reference sources and definitions.

Defining 'natural capital'

The concept of 'natural capital' aims to underline the role of nature in supporting the economy and human well-being. Natural capital is part of different types of capital which all play a role in societal and economic development. These also include manufactured capital, human capital and social capital all of which also draw on natural capital.

Natural capital comprises of the ecosystems and abiotic assets of the planet that provide people with exploitable resources, e.g. forests, solar radiation, water, fossil fuels and minerals. Its component 'ecosystem capital' generates a flow of benefits via ecosystem services, e.g. food, climate regulation and recreation.

The role of natural capital accounting

The global System of National Accounts (SNA) provides core economic indicators, e.g. GDP, that are useful for economic policy-making. However, to better understand the impact of our economic activities on the environment, it is important to develop complementary natural capital accounts. This would allow measuring the contribution of natural assets and associated service flows to our economy and well-being, and help monitor the changes in natural capital – that we ultimately depend upon.

Accounting systems are designed to bridge the gap between detailed environmental data and the information needed by the public and decision-makers to ensure long-term sustainability. They provide a structured framework for connecting economic activities to their environmental impact and for aggregating different measurements (of natural capital) across environmental issues and spatial scales. The objective of accounting can be limited to analysing bio-physical trends in a structured manner but many accounting approaches aim to support the valuation of natural capital (in monetary or non-monetary terms).

The development of environmental accounting

The UN's Rio Conference on Sustainable Development in 1992 called for the creation and use of integrated environmental and economic accounting methods. As a response, the UN System of Environmental-Economic Accounting (SEEA) provides a systematic framework to collect information on the state of natural capital. Its Central Framework (SEEA-CF) sets out an approach for environmental resource accounts to measure the stock and flows of abiotic resources and some biotic resources. The experimental ecosystem account handbook (SEEA-EEA) provides methodological guidance for the measurement of ecosystem assets and services.

Other global initiatives also provide methodological guidance and support pilot projects in the area of natural capital accounting and valuation of ecosystem services. The most prominent among them are the TEEB process on '*The Economics of Ecosystems and Biodiversity'* (TEEB), the World Bank's '*Wealth Accounting and the valuation of ecosystem services'* (WAVES) project, and the CBD 'Quick Start Package' on '*Ecosystem Natural Capital Accounts'* (ENCA).
A range of work is underway in Europe. Through Regulation (EU) No 691/2011 on European environmental economic accounts (amended in 2014), the EU has established an overall legal framework for environmental accounting. A pilot project under the EU MAES process to support the implementation of targets in the EU biodiversity strategy has led to this reference document, which provides guidance on the ecosystem component of natural capital accounting. The European Environment Agency (EEA) is developing simplified ecosystem capital accounts for use at EU level. And many European countries are developing national approaches to account for (components of) natural capital, with several of them being quite advanced. In addition, EU research funding supports substantial projects on developing and/or implementing natural capital accounting methods.

Informing policy decisions via natural capital accounting
Natural capital accounting is a potentially useful tool for policy-makers from EU to regional level as it helps to understand the links between economic sectors and the environment at different spatial scales. This document reviews opportunities in key EU policy areas: water policy, biodiversity policy and Cohesion Policy.
The added-value of the approach depends on the maturity and quality of the accounts, the data they build on, and on other existing indicators and measurement tools already contributing to the evidence base for policy-making. Their relevance will grow as accounting systems and input data sets develop and practical experience is gathered in their implementation.

Taking natural capital accounting forward
Natural capital accounting enhances the knowledge base on natural resources and ecosystem assets and helps us to assess whether natural capital is managed within sustainable limits. A lot of progress has already been made on developing concepts and methodology. So the time is ripe for implementation and learning from experimentation. In parallel it is necessary to plan ahead and set strategic goals. For this purpose the concluding chapter proposes a draft roadmap for natural capital accounting in the EU which is organised under four main headings:

a) Developing a clear conceptual focus
b) Building a suitable common data platform
c) Establishing an effective organisational set-up
d) Making accounts part of policy practice

Work at EU and national level along these lines will help to build the conceptual and practical foundations for the ambitious natural capital accounting targets contained in the EU Biodiversity Strategy and 7th Environmental Action Programme of the European Union to be achieved.

1 Accounting for natural capital: Methodological frameworks and challenges

The global System of National Accounts (SNA) provides core economic indicators, e.g. GDP, that are useful for economic policy-making. However, to better understand the impact of our economic activities on the environment it is important to develop complementary natural capital accounts. This would allow measurement of the contribution of natural assets and associated service flows to our economy and well-being and help monitor changes in the natural capital that we ultimately depend upon.

The UN System of Environmental-Economic Accounting (SEEA) provides a systematic framework to collect information on the state of natural capital. SEEA is a key approach, in particular as it is linked to the SNA. Its Central Framework (SEEA-CF) sets out an approach for environmental resource accounts to measure the stock and flows of abiotic resources and some biotic resources. The experimental ecosystem account handbook (SEEA-EEA) provides methodological guidance for the measurement of ecosystem assets and services.

Accounting systems hold the promise of bridging the gap between detailed environmental data and the information needed by the public and decision-makers for a better management of natural capital assets. A range of initiatives are developing approaches for the accounting of different types of natural capital. However, there are various methodological challenges, ranging from measuring components that are difficult to quantify (e.g. cultural services) to developing sufficiently accurate and complete physical accounts and to identifying suitable economic valuation approaches.

1.1 Introduction

This chapter reviews conceptual and methodological aspects of natural capital accounting. The starting point is a brief discussion of how the environment is integrated into current national accounting systems and decision-making. Then it discusses the system of integrated environmental and economic accounts (SEEA) and how this relates to natural capital accounting. This includes the development of physical asset accounts as well as a brief discussion of monetary valuation approaches. The chapter concludes with a review of general principles for constructing accounting frameworks.

Before going into the details of environmental accounting, it is necessary to reflect on how accounting systems deal with nature and the need to understand the 'ecosystem/economy boundary'. This concept arises from the utilitarian perspective that underpins environmental-economic accounting. Any accounting system divides whatever it measures into different categories, otherwise it could not function. So the purpose of environmental-economic accounting is not to analyse how nature functions in all its complexity, but to measure how humans benefit from nature, thereby helping to better manage natural capital at local, national of global scale.

The benefits that human society derives from exploiting abiotic capital, in the shape of e.g. minerals, gravel and fossil fuels, are fairly obvious - although the negative side effects of exploiting fossil resources also need to be accounted for. However, this becomes more complicated regarding the benefits derived from ecosystem capital. Ecosystem services are defined as the 'contributions that ecosystems make to human well-being'. So at what point do ecosystem assets or flows become 'contributions', and what does the term 'human well-being' actually mean? One concept that is used frequently in this regard is the 'ecosystem/economy boundary'. This implies that only those parts of ecosystem assets or flows that have a direct or indirect utility for human society, i.e. increase our well-being, can be translated into measurable contributions. These are often called 'ecosystem benefits' - see Figure 1 for a representation of these concepts.

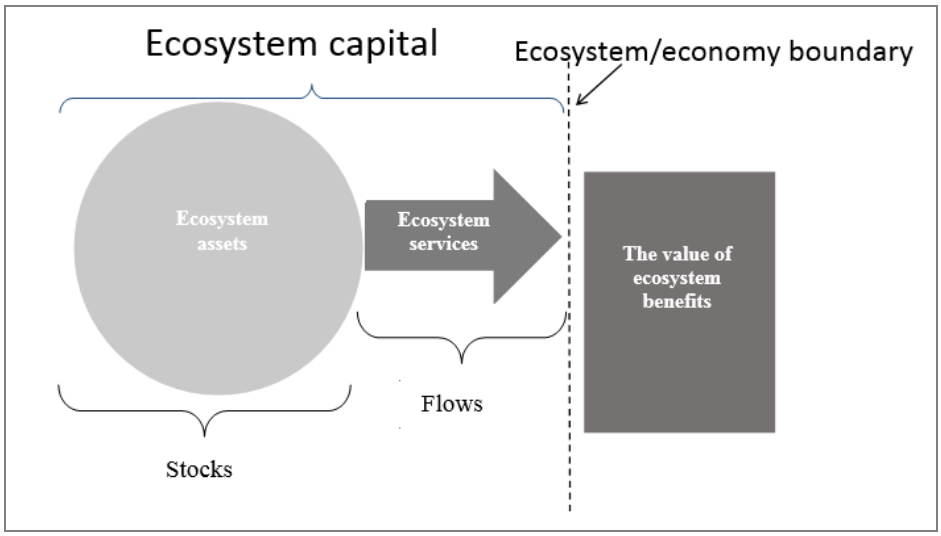


Figure 1 Natural Capital and ecosystem benefits
Based on UNEP (2014): Towards a global map of natural capital: key ecosystem assets.

Traditional accounting approaches only capture the economic value of products or services derived from nature on the right hand side of Figure 1. Natural capital accounting, however, aims to show how ecosystem assets and service flows are developing to give us an early warning system for managing ecosystem capital better.

1.2 Natural capital, accounting systems and decision-making

National Accounts and information on natural capital

The internationally-accepted and well-established System of National Accounts (SNA) provides a standard methodology for drawing-up national economic accounts. These accounts document the factors of production and consumption in the economy.

SNA accounts are the main source of information for internationally comparable indicators such as: Gross Domestic Production (GDP), value-added, national income, consumption, economic growth rate, or government deficit. SNA-derived indicators are used to track the economic performance of sectors and the flow of money between different sectors and households, salaries, purchases of goods and services, public and private investments and savings. The main point is that the accounts on which they are based represent an agreed way of synthesising information in consistent, meaningful and relevant ways so that comparisons can be made and decisions taken – relating to economic growth, employment or the reduction of government debt.

Despite the very real achievements and value of SNA accounts, they only include some components of natural capital, e.g. agricultural output or timber values. Most ecosystem services are not in the accounts because they provide public goods which do not generate market revenue and hence cannot be included in the SNA.

Human use of ecosystems and their services can lead to the depletion and degradation of natural capital. Where taken too far, this can lead to irreversible damage where a critical threshold is passed (Rockström *et al.*, 2009). This implies that negative side effects from exploiting natural capital, in all its forms, also need to be accounted for. For this reason, it is important that decision-making processes at the international, national, regional, local and business levels take into account not only economic performance, but also the role of nature in the economy. This means that economic accounts need to be complemented with environment-focused accounting approaches to ensure that public and private decision-makers consider natural capital in their planning processes.

If natural capital accounting is to have a positive impact on economic and environmental decision-making it needs to help fill in 'knowledge gaps' by providing a more complete picture of the interaction between economy and environment. There are two sides to this interaction: one is to

improve the management of natural assets that provide public goods, the other is to avoid negative effects from economic activities that can damage natural capital, directly or indirectly.
Since the SNA only includes goods and services that are traded in markets, i.e. 'private' ones, complementary accounts are needed to help us understand what is going on – in particular, to the public goods and services provided by ecosystem capital. These include, above all, regulation and maintenance services as well as cultural services. Some of these are of global nature, e.g. climate regulation, which require global cooperation for critical underlying assets to survive into the future, e.g. rain forests. Others may provide benefits at regional or local level, for example forest stocks can help even-out water flow regimes within a water basin, as well as provide local opportunities for recreation. In this context, a better understanding of the spatial distribution of ecosystem assets can help to identify how inter-regional or cross-border flows of ecosystem services might mean that the benefits enjoyed in one country depend on the good management of natural capital stocks in another.
Economic growth derived from the over-use of different types of natural capital, e.g. fish stocks or forests, as well as the pollution of air and water via industrial activities, can lead to short-term economic benefits. However, in the long-term it does not really contribute to an increase in our total wealth if it destroys critical natural capital assets.
The issue of how to account and deal with the degradation of natural capital due to over-use, pollution or other factors is, therefore, another reason for natural capital accounting. This offers the possibility of estimating the 'ecological debt', that is transferred to other countries or future generations, by importing goods, over-exploiting ecosystems or exporting waste flows (Martinez-Alier, 2005, and Weber, 2012).

Accounting systems and the use of information in decision-making
Edens and Hein (2013) and van Dijk *et al.*, (2014) have reviewed current approaches to natural capital accounting and focused, specifically, on the issues arising from the goal of integrating ecosystem services and natural capital into national accounts, and how to provide information to decision-makers. Figure 2, below, illustrates their thinking on the use of information in decision-making.

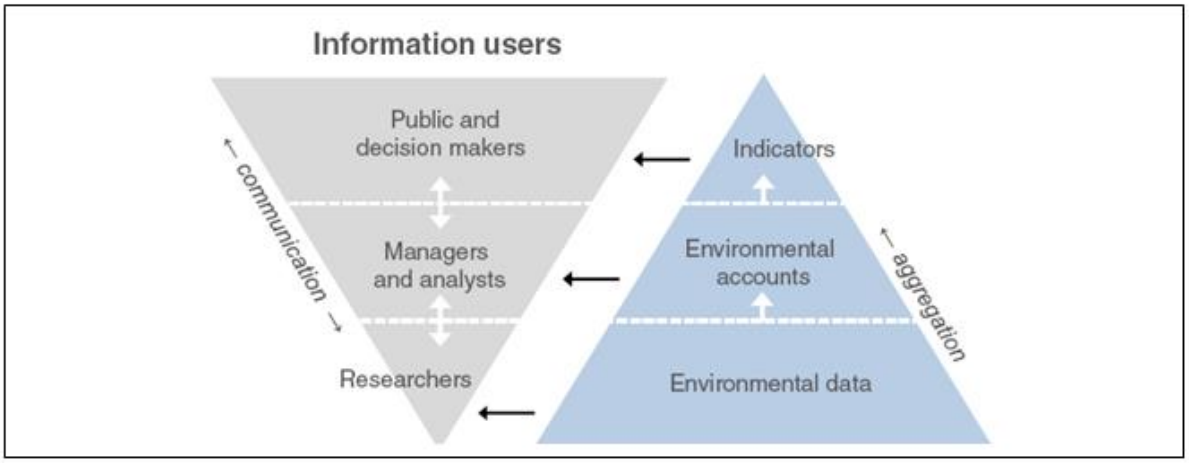


Figure 2 The role of natural capital or environmental accounts (after van Dijk *et al.*, 2014)

Van Dijk *et al.* (2014), highlighted the particular dangers of ad hoc approaches to data collection and reporting. They suggested that a lack of standardisation and long-term perspectives will lead to increased costs – in terms of data sharing and coordination, and over-reliance on particular data sources that are easy to acquire even though they may not be entirely fit-for-purpose. These commentators see accounting systems as bridging the gap between underlying and comprehensive data infrastructures and the higher level indicators and metrics that decision-makers use for identifying policy priorities, and also as a means of communicating with the public (see Figure 2).

In designing such accounts, the accounting challenge is to find ways of aggregating data efficiently, without loss of information, and the presentation of them in ways that have meaning for managers and decision-makers working at different levels. The next section describes the main directions that this work is taking.

1.3 The System of Integrated Environmental and Economic Accounting (SEEA)

The need for complementary measurements and accounting, for both the economy and nature, has been the stimulus for the development of the System of Environmental-Economic Accounting (SEEA). The initiative is led by the United Nations Statistical Commission (UNSC), through the London Group on environmental accounting, which operates under the auspices of the UN Committee of Experts on Environmental-Economic Accounting (UNCEEA).

The SEEA is designed to provide a systematised framework to carry out natural capital accounting and the measurement of natural capital – in terms of the biotic and abiotic assets that compose it, their degradation or restoration as a result of interactions with the economy and society, and the flows of goods and services they provide.

Figure 3, below, presents an overview of where the different components of the SEEA seek to provide a fuller picture of the interactions between the economy and the environment and, hence, the way it extends the coverage of the SNA.

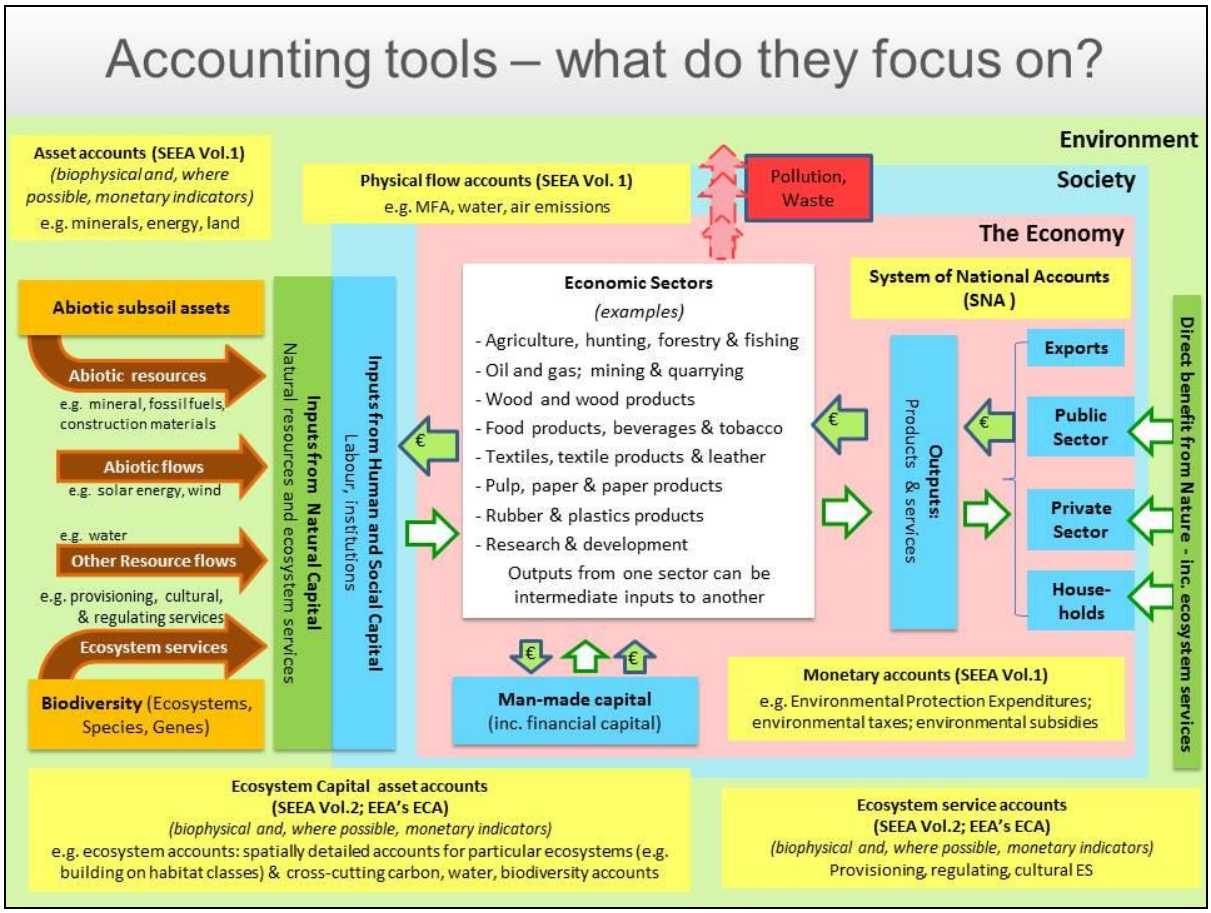


Figure 3 Overview of SEEA components extending the coverage of the SNA
Source: adapted by ten Brink, Mazza, Dekker and Russi from ten Brink *et al.*, 2011.

Conceptually, the SEEA provides a set of tables that are consistent and can be integrated with the SNA structure, classifications, definitions and accounting rules. In this way, an analysis of changes in the status of natural capital can be documented – with its contribution to the economy and the impacts of economic activities. The SEEA also provides detailed methodological guidance to prepare

environmental-economic accounts on a wide range of issues. The approach is for each country to select the modules that it is interested in, according to their political priorities, resource availability and data accessibility. It should be noted that within the EU Regulation 691/2011 (amended in 2014) sets the frame for implementation of the different SEEA modules.
The most recent revision of the SEEA is described in a three volume set, which consists of:

- ***SEEA Central Framework*** (SEEA-CF): The environmental resource accounts which measure, in physical and monetary terms, the stock of natural resources and the flows that cross the boundary between economy and the environment and circulate within the economy.

  It focuses on the abiotic components of natural capital, e.g. minerals and energy, although it also includes some biotic components of natural capital, e.g. timber. It also includes material flow accounts (MFA) and waste, water and air emission accounts as well as environmental transfers, expenditures and environmental activities (see Table 3.1 below).
- ***The Experimental Ecosystem Accounts*** (SEEA-EEA): At present, this is a methodological guidance document rather than a formal statistical standard. It aims to show how to measure ecosystem components of natural capital, in terms of the state of ecosystems and their capacity to provide ecosystem services, as well as estimates of the costs of protecting or repairing damage. The aim is to develop accounts for important natural capital stocks such as carbon, water and biodiversity, and ecosystem service flow accounts initially using quantitative physical metrics. Over time, these might become expressed in monetary terms – depending on methodological suitability.
- ***Extensions and applications of the accounts*** (SEEA - AE): Among other things, this volume describes examples of analytical and policy uses of natural capital accounts. It aims to be a guide to practitioners on the development and analytical use of environmental accounting approaches. See: http://unstats.un.org/unsd/envaccounting/ae_white_cover.pdf

Table 1 shows the different types of accounts that are included in the SEEA-CF and SEEA experimental ecosystem accounts and an example to illustrate their potential format is provided in Table 2 below. The different types of accounts will be explained in more detail in Sections 3.4 and 3.5 where the particular challenges that arise in their construction are identified.

Table 1 Component accounts of the SEEA

SEEA Central Framework (SEEA-CF)		SEEA experimental ecosystem accounts (SEEA-EEA)	
Assets	***Flows***	***Assets***	***Flows***
In principle both physical and monetary accounts for: • Mineral and energy resources • Land • Soil resources • Timber resources • Water resources • Other biological resources	*In principle both physical and monetary accounts for*: • Energy • Water • Material flows • Air emissions • Waste water • Solid waste *Monetary accounts for:* • Environmental protection expenditure • Environmental goods and services sector • Environmental taxes and environmental subsidies	*In principle both physical and monetary accounts for*: • Land accounts • Carbon accounts • Water accounts • Soil and nutrient accounts • Accounts for different types of ecosystems • Biodiversity accounts	*In principle both physical and monetary accounts for:* • Provisioning ecosystem services • Regulation and maintenance ecosystem services • Cultural ecosystem services

Table 2 Example of an accounting table

Basic form of an asset account
Opening stock of environmental assets
Additions to stock
Growth in stock
Discoveries of new stock
Upward reappraisals
Reclassifications
Total additions of stock
Reductions of stock
Extractions
Normal loss of stock
Catastrophic losses
Downward reappraisals
Reclassifications
Total reductions in stock
Revaluation of the stock
Closing stock of environmental assets

As a contribution to the international work that surrounds the development of the SEEA, and especially the work involving the issues in SEEA-EEA, the European Environment Agency is developing simplified ecosystem capital accounts (sECA). This initiative aims to build the first application of experimental ecosystem accounts, covering at the minimum biomass carbon, water quantity and land (use), based on the available data at European level.

1.4 Physical natural capital accounts

Ecosystem assets and the ecosystem service flows they generate are generally physical entities – so developing physical accounts expressed, using units such as areas, weights, volumes or counts, is the first logical step to take. Current approaches envisage physical accounts sitting usefully alongside economic information as a set of 'satellite accounts'. Subsequent valuation for policy purposes may include monetisation approaches, but not necessarily so.

The physical accounts form part of the SEEA Central Framework (SEEA-CF) and the Experimental Ecosystem Accounts (SEEA-EEA) measure both the stock assets and flows. The accounts included in the SEEA-CF collect information on:

- ***Physical assets*** represented by the available stock of natural resources and their changes due to extraction, new discoveries, natural growth, natural disasters and other reasons. They include asset accounts for mineral and energy, together with those for land and soil resources, timber resources, water resources, and accounts for other biological resources;
- ***Physical flows between the economy and the environment*** for inputs, e.g. energy accounts, water accounts, and material flow accounts, and outputs, e.g. air emission accounts, waste water accounts, and solid waste accounts.

In the context of the SEEA-EEA, ecosystems are regarded as assets and ecosystem services as the 'flows' of benefits that they provide to people. The SEEA-EEA defines ecosystem assets as *spatial areas containing a combination of biotic and abiotic components and other characteristics that* function together (SEEA-EEA, p. 23).

The SEEA-EEA, therefore, represents an important conceptual shift, compared to the approach of the SEEA-CF. The SEEA-CF considers assets more or less individually, e.g. in terms of energy resources, water, minerals, land, and timber. The SEEA-EEA sees environmental assets from a broader perspective – accounting aims to assess how different environmental assets interact as part of natural processes, in specific locations, in providing ecosystem services.

Thus the accounts in the SEEA-CF looks at the relationships between, for example, land cover, land use, carbon, biomass, and water provision. Differing from the SEEA-CF, the SEEA-EEA focusses only on biotic assets and the services which flow from those assets.

Most progress has been made so far in developing accounts for abiotic assets and the flows of benefits derived from them. In many instances, accounts are also available for ecosystem assets that provide marketable goods, e.g. forests. Future developments will extend the accounts to cover ecosystem services.

This requires a standardised approach which is provided by the Common International Classification of Ecosystem Services (CICES). CICES (see Table 3) now forms part of the SEEA-EEA.

Table 3 The CICES 4.3 classification of ecosystem services (first three levels)

Note: CICES is hierarchical in structure, and only the first three levels are shown in Table 3 (see www.CICES.eu)

Section	Division	Group
Provisioning	Nutrition	Biomass
		Water
	Materials	Biomass, Fibre
		Water
	Energy	Biomass-based energy sources
		Mechanical energy
Regulation & Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota
		Mediation by ecosystems
	Mediation of flows	Mass flows
		Liquid flows
		Gaseous / air flows
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection
		Pest and disease control
		Soil formation and composition
		Water conditions
		Atmospheric composition and climate regulation
Cultural	Physical and intellectual interactions with ecosystems and land-/seascapes [environmental settings]	Physical and experiential interactions
		Intellectual and representational interactions
	Spiritual, symbolic and other interactions with ecosystems and land-/seascapes [environmental settings]	Spiritual and/or emblematic
		Other cultural outputs

The SEEA-EEA proposes to account for ecosystem assets by measuring the extent and condition of different ecosystems and their services. This requires geo-referenced data that at least provide a proxy distribution for the different types of ecosystem assets of interest. This approach provides scope for synergies, and a need for coordination, with the activities on mapping and assessment of ecosystems and their services as part of the wider EU *MAES* process.

1.5 Monetary accounts and valuation approaches

1.5.1 Monetary measurements in the SEEA-CF

Monetary accounts and associated indicators are included in both the SEEA-CF and the SEEA-EEA. The Central Framework contains a number of such monetary measurements, including:

- ***Environmental protection expenditure accounts (EPEA)***, covering expenditures on pollution prevention and abatement;
- ***Environmental goods and services sector accounts*** providing information on environmental goods and services such as waste and wastewater management and treatment services, and energy and water saving activities;
- ***Environmental taxes;***
- ***Environmental subsidies;***

- ***Water and waste water;***
- ***Energy accounts.***

While the SEEA-CF recognises that many aspects of the environment can be accounted for in physical and monetary terms, the scope of monetary valuation in the SEEA-CF is limited in scope since generally only assets that have a market price are included. Monetary accounting for those that lie outside any market is one of the challenges to be tackled in developing experimental ecosystem accounts.

1.5.2 Enlarging the scope to value ecosystem goods and services

To overcome the challenge of valuing ecosystem assets and services that are not traded in markets, and which therefore do not have a price, economists have proposed a number of different methodologies for the monetary valuation of ecosystem services, (White, *et al.*, 2011; ten Brink, (ed.), 2011; Pascual, *et al.*, 2010; Kumar, P., 2012; United Nations *et al.*, 2014). In this context it should be noted that the value of ecosystems, i.e. assets, can be approximated using the sustained flows of ecosystem services they provide. For example forests provide regulating ecosystem services, e.g. carbon storage, provisioning ecosystem services, e.g. timber, and cultural ecosystem services, e.g. recreational settings.

Analysis for the European Commission identifies three main methodologies (Brouwer, *et al.*, 2013):

1) Methodologies based on ***costs***, which use market prices to indirectly estimate the monetary value of ecosystem services. Examples include: methodologies based on the avoided costs, e.g. economic damage from floods by managing floodplains in a sustainable way; replacement costs, e.g. the cost of mechanical purification of water which is needed to replace natural water purification provided by healthy ecosystems; restoration costs which calculate the cost of restoring a degraded ecosystem.

2) Methodologies based on ***revealed preferences*** that are estimated values based on the preferences of individuals – as shown by their behaviour, e.g. the Travel Cost Method and Hedonic Pricing. The former can be used to estimate the value of a protected area through the amount of time and money people spend to visit it. The Hedonic Pricing Method uses the changes in the market value of goods that are directly related to the ecosystem services to be valued, e.g. differences in property prices can be used as indicators of the cultural ecosystem services provided by the landscape.

3) Methodologies based on ***stated preferences***, e.g. Contingent Valuation – which is based on the preferences that are directly stated by people through surveys. They investigate people's willingness to pay (WTP) for improved environmental conditions, or their willingness to accept (WTA) compensation for a reduction in environmental quality.

Since monetary valuation studies are time and resource intensive, in many cases monetary values calculated elsewhere for similar ecosystems are used. This procedure is called value or benefit transfer and must be carried out with caution because the provision and the value of ecosystem services is often location-specific (Pascual, *et al.*, 2010; Brouwer, *et al.*, 2013, section 6.2.4.3; SEEA-EEA, section 5.6.3).

A review of national ecosystem service assessments across the EU Member States (Brouwer, *et al.*, 2013) found that most studies cover different kinds of provisioning, regulating, cultural and supporting ecosystem services, but only a small subset of them used monetary valuation in their assessments. In general, monetary valuation of ecosystem services is, therefore, still at a very early stage. The review found that most provisioning services are, or will be, valued using market prices. Most regulating services using methodologies based on costs, where possible. Monetary valuation of

cultural ecosystem services, which are mainly valued using stated valuation methods, is much more complicated because of the methodological challenges, lack of data, lack of resources to conduct original valuation studies and criticisms towards the use of monetary non-market valuation in some countries.

If different methodologies are used for monetary valuation, then the values obtained for different ecosystem services are difficult to aggregate because they are not directly comparable. A particular issue is that market prices for goods should ideally not be conflated with economic values derived from methods such as 'willingness to pay'. This may pose a problem if monetary valuation is to be used for accounting purposes (Brouwer, *et al.*, 2013). Overall, there is not yet an agreed method for integrating monetary measurements across different types of accounts and considerable methodological challenges remain. Further national experimentation is crucial to identify potential ways forward.

1.5.3 Non-monetary valuation methods

Since monetary valuation is still at a very early stage, some studies used non-monetary valuation methods as an alternative to aggregate and weigh different ecosystem goods and services. The term 'non-monetary valuation' refers to a broad and heterogeneous collection of approaches and methods (Christie, *et al.*, 2012). Non-monetary valuation techniques do not translate the value of ecosystem services to money flows, but express their importance with relative ranks reflecting stakeholder perspectives. By avoiding reducing plural values into one single metric, these methods are able to grasp both tangible and intangible benefits derived from ecosystems (Chan, *et al.*, 2012).

It is important to note that preferences are often very contextual. Some issues may be overlooked, e.g. if only parameters are considered that have an economic value in the market place, as in the case of some Payments for Ecosystem Service (PES) schemes. However, while non-monetary methods might offer a broad approach, they do not always mesh well with natural capital accounting principles and tend to be applied in more case-specific decision-making.

1.6 Developing ecosystem accounts within an overall framework

The review provided here suggests that while it is generally acknowledged that natural capital accounting is needed the ways to account for natural capital, i.e. the methodologies and principles needed to achieve this ambition, are still under development. A number or recent initiatives are, however, beginning to show the direction that practical applications are taking.

There are, for example, discussions between the UN-SD, UNEP, World Bank, and others, to develop guidance on ecosystem accounting that builds on the SEEA-EEA principles (Hein, 2014, pers. comm). One of issue being considered is which accounts should be part of the UN Ecosystem Accounting approach. A preliminary view is that they should include:

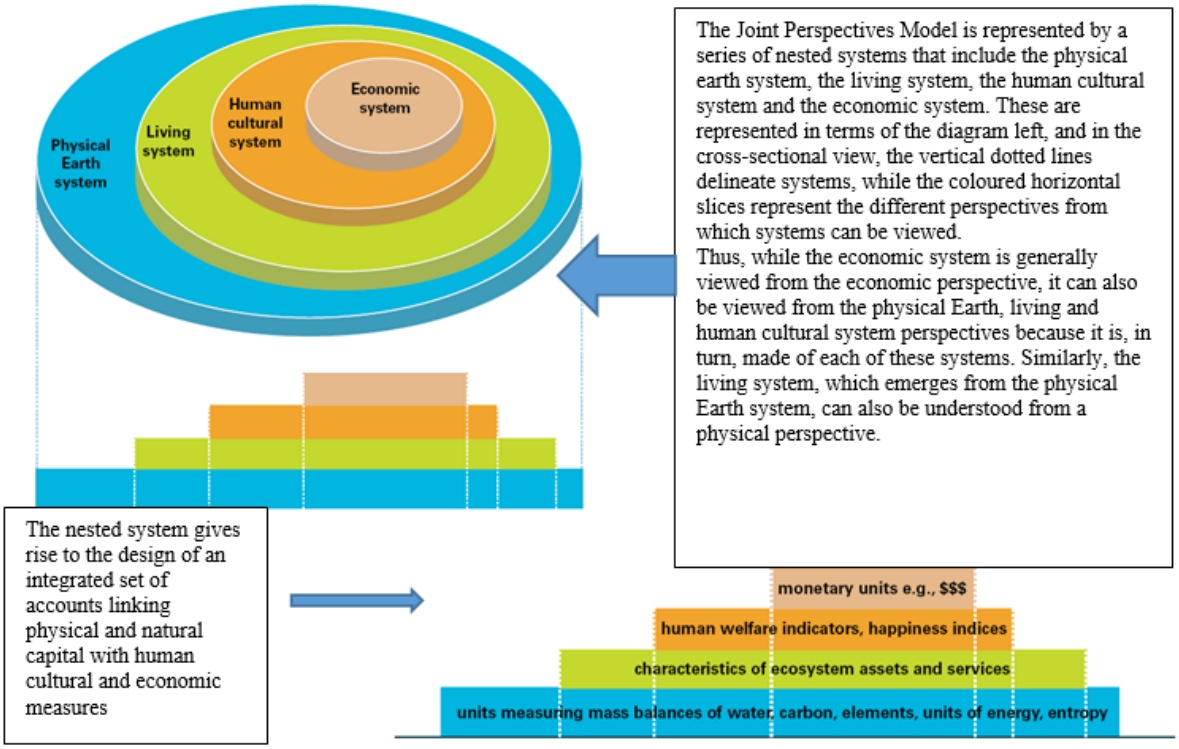
- ecosystem asset accounts, which describe in physical and monetary terms the stocks of ecosystem capital and their changes over time;
- ecosystem condition accounts, which describe the status or integrity of the ecosystem accounting units in some way, so that judgements about the extent of changes in the capacity of the assets to deliver ecosystem services can be made;
- ecosystem service flow accounts, which describe the outputs of services in both non-monetary and monetary terms;
- the supply-use account connecting suppliers and users, as classified by the classified by the International Standard Industrial Classification (ISIC);
- biodiversity accounts that record levels and changes in species composition.

Such a framework is consistent with those being suggested both in Australia and the UK, which also draw upon the foundation of the SEEA-CF and SEEA-EEA, and which seek to emphasis a more purpose-driven approach. The framework also emphasises that, while monetary accounts are useful, the development of physical accounts is perhaps more fundamental in the sense that it provides the foundation for the former. The emerging paradigm is perhaps best illustrated by the work in Australia (Bureau of Meteorology, 2013) which is based on a 'joint perspectives model' (Box 3.1). This is used to represent the core relationships between the economy, society, and environment. It envisages four nested systems: the physical earth system, the living system, the human cultural system, and the economic system – these collectively define the scope of any set of environmental accounts. The idea of nesting is used to emphasise the need to be able to used accounts to 'transfer value between places, times and entities' and, especially, to show how physical accounts for the earth and living systems can be relevant to social and monetary accounts at the level of cultural and economic systems.

It is envisaged that for:

- **Physical and Living systems** accounts would be based on physical measures, and that those for natural capital would document ecosystem assets and flows, together with measures of their functions and processes, biodiversity, biocarbon cycle, water cycle. The accounts would primarily be defined spatially using classifications of land cover, habitat, ecosystems, or environmental assets;
- **Human cultural systems** relevant accounts would include those for ecosystem services that would document the benefits flowing directly to human cultural systems that are outside the economic system. The accounts would use indices of human well-being, suffering, and happiness, measured at the scales of individuals, groups, municipalities, communities, societies, and nations;
- **Economic systems** ecosystem service accounts would also be a key part, but here they would be measured in market-based values and captured in the SNA measured at the scale of individuals, households, businesses, enterprises, and nations etc.

Although the scope of the accounting framework suggested is very broad, the Australian work has gone on to provide a series of practical guidance documents, (Bureau of Meteorology, 2013), designed to help people understand the process of framing and using an environmental account.



Box 1 The Joint Perspective Model (after Bureau of Meteorology, 2013)

The UK work (NCC, 2014) has also focussed on making practical advances in accounting methodologies by looking at specific purposes and needs – their principles currently focus on providing a framework for developing accounts for ecosystems and ecosystem services, rather than natural capital accounts, which is interpreted as being much broader in scope and encompassing elements relating to the SEEA Central Framework.

Thus sub-soil assets are not included within the scope of ecosystem accounts, along with accounts for the atmosphere, minerals and the oceans. However, in keeping with the SEEA it is envisaged that development should be guided by such things as economic and policy relevance, the extent to which ecosystem services can be influenced by interventions, and the existence of adequate data and methods for quantifying and valuing the services.

The UK principles go on to describe assets accounts that document the stock, condition and other characteristics of an ecosystem unit, and ecosystem service accounts that document the flow of services, in non-monetary terms, for an accounting area. The service accounts describe both the supply and use of services, and like the Australian framework use land cover and habitats to disaggregate and report the information. It is also envisaged that accounts for biodiversity will be provided as part of the accounting exercise.

1.7 Summing up:

Natural capital accounting enhances the knowledge base on natural resources and ecosystem assets and helps us to assess whether natural capital is managed within sustainable limits. A lot of progress has already been made at international level in developing related environmental accounting concepts and methodology. This is particularly strong for physical accounts that aim to measure trends in the natural asset base as well as (ecosystem) service flows.

More work is clearly required with regard to economic valuation, both for monetary and non-monetary approaches. However, physical accounting approaches need in any case to be completed first as they provide a necessary platform on which to build economic valuation

A key conclusion to emerge from ongoing work is that future efforts to develop natural capital accounting should be targeted and purpose-driven. The need to focus efforts around specific needs and priorities is also emphasised in a recent CBD publication on 'ecosystem natural capital accounts', which provides a 'Quick-Start Package' designed to help implement the Aichi Biodiversity Target 2 on integrating biodiversity in national accounting systems.

Overall the foundation has been established for practical implementation and learning from experimentation at national and EU level. Such a process would benefit from further exchange between interested Member States and the development of an overarching strategy. In the context of the EU MAES process chapter 5 proposes a draft roadmap to strengthen momentum and capacity across Europe for taking natural capital accounting forward.