DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS
STATISTICS DIVISION
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System of Environmental Economic Accounting

# SEEA EEA Revision

# Expert Consultation

# Working group 1: Spatial units

# Discussion paper 1.3:
# *Treatment of the atmosphere and oceans in the SEEA EEA*



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# Research area #1: Spatial units

# Discussion paper 1.3: Treatment of the atmosphere and oceans in the SEEA EEA

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## The SEEA EEA revision process

Spatial units are at the heart of ecosystem accounting. The focus to date has been the development of a measurement approach that enables relatively broad scale terrestrial ecosystems to be accounted for. The general approach for delineating these areas has become relatively well established although there are still important matters requiring resolution.

The key focus in this research area is to establish statistically and accounting relevant classifications for ecosystem types with careful review and application where possible of existing classifications of this type. Worldwide, there have been many efforts on mapping land, including land cover, land use etc. For statistical purposes it is necessary to have an agreed set of classes using a common set of principles such that mapping exercises in different countries and locations can work towards a common measurement goal. It has been recognized that for ecosystem accounting, in principle, we need to go beyond land cover and consider a wider range of characteristics in delineating ecosystem assets.

The delineation of ecosystem assets will, ideally, involve the use of a range of ecological and non-ecological criteria, including vegetation type, soil type, hydrology, and land management and use. Distinct focus should also be placed on the description and classification of marine areas given the strong interest in applying ecosystem accounting for these areas. Also, consideration should be given to articulating the connection to atmospheric units in order to complete a spatial delineation of the environment. Furthermore, there is an emerging interest concerning ecosystem accounting for urban areas considering the large proportion of the work population living in cities. These should be distinguished from areas defined in terms of land cover or use as built-up areas and instead considered as a combinations of multiple ecosystem types.

Although these topics have seen significant progression from the initial (interim) land cover classification in the SEEA Central Framework (2012), and subsequently the guidelines provided by The Experimental Ecosystem Accounting (2012) and the recent Technical Recommendations (2017), several issues remain unsolved and need to be addressed in the current revision process.

This paper is part of a series of discussion papers on spatial units. It aims to **provide guidelines how to deal the atmosphere and the marine environment in an ecosystem accounting context, particularly with regard to the delineation as spatial units.** Two other papers are part of this series: a paper that provides options for the construction of a reference classification of ecosystem types and guidance for further disaggregation for ecosystem accounting at a national or regional scale (Discussion paper 1.1) and a paper that proposes guideless for urban accounting (Discussion paper 1.2).

These discussion papers have been developed by a working group established as part of the revision process. The working group on spatial units is one of five working groups for the four research areas (RAs) identified in the Revision Issues Note: RA1 focuses on spatial units, RA2 on ecosystem condition, RA3 on ecosystem services and RA4 on valuation.

In terms of next steps we seek a) feedback on the proposed principles and criteria, and b) feedback on the classification options and other materials in the paper. In addition, we recognize that we need to move to a testing phase involving the extent to which leading options can be mapped in practice and the extent to which the leading options can be mapped to existing national classifications.

# 1. Introduction

The oceans and the atmosphere play a key role in the earth ecology and environmental processes. Furthermore, they interact with economic activities and processes, for example by providing natural resources and specific ecosystem services, but also by receiving residuals. The SNA (2008), SEEA CF (2012) and SEEA EEA (2014) provide some guidance how to deal with the oceans and atmosphere in terms of assets and flows. However, some important issues are still not quite resolved or need some further elaboration.

In the description of SEEA EEA revision issues relating to spatial units, there is reference to the need to investigate the definition of spatial units related to the atmosphere. The text notes:

> "…consideration should be given to articulating the connection to atmospheric units in order to complete a spatial delineation of the environment. Defining atmospheric units is relevant, for example, in advancing carbon accounting but also in supporting the connection of flows such as GHG emissions to the ecosystem accounting framework."

The current SEEA EEA is based on a fundamentally two-dimensional view of the relationships within the environment where ecological structures are described fully within the biosphere and ecological processes are effectively limited to taking place within the biosphere. While this certainly covers important structures and processes, there are limits to this framing that have an effect on the potential to use ecosystem accounting to fully articulate environmental condition and flows. This is particularly true for the atmosphere. Currently, it is not clear how the atmosphere should be treated in the context of ecosystem accounting.

The same issue also applies to marine environments. Marine ecosystems (in particular deep pelagic areas) are often best described in three dimensional terms. This does not go together well with the two dimensional approach of delineation of ecosystem assets as described in the SEEA EA.

The main purpose of this discussion paper is to explore how to atmosphere and the oceans are currently treated in SEEA and propose how this can be further improved, or where necessary be clarified. In order to do so, we also have to revisit the definition of ecosystem assets and see if this definition needs some modification or clarification. We will focus on answering the following issues:

1. What is the current treatment of the atmosphere and the seas/oceans in the SNA, SEEA CF and SEEA EEA.
2. What is the nature of ecosystem assets in SEEA EEA? Are they 2 or 3 dimensional entities? Should the definition of ecosystem asset be modified ?
3. Should the atmosphere be seen as a separate unit or should it be considered being part of other ecosystem assets ?
4. Should the spatial approach also be applied to all parts of the oceans or should we distinguish different ecosystem assets also in a vertical direction?

In section 2 the current treatment of the atmosphere and oceans in respectively the SNA, SEEA CF and SEEA EEA are described and discussed. In section 3 we discuss the nature of ecosystem assets and propose some clarifications/modifications with regard to its definition. In sections 4 and 5 options are presented and discussed with regard to the treatment of the atmosphere and the marine environment in SEEA EA respectively.

# 2. Current treatment in the SNA, SEEA CF and SEEA EEA

In this section we explore how the atmosphere and oceans are currently treated in the SEEA EEA (2014). Starting point is to look at how assets (economic assets – environmental assets – ecosystem assets) are defined and how these definitions relate to the atmosphere and the oceans. To do so, we must also look at the Systems of National Accounts (SNA) (2008) and the SEEA Central framework (2012) in order to understand the relationships between the frameworks and to ensure a consistent treatment.

## 2.1 SNA

In the SNA2008 economic assets are defined as ***entities that must be owned by some unit, or units, and from which economic benefits are derived by their owner(s) by holding or using them over a period of time*** (SNA 1.46). The ownership criterion is particularly important for determining which natural resources are treated as assets in the SNA. Natural resources such as land, mineral deposits, fuel reserves, uncultivated forests or other vegetation and wild animals are included in the balance sheets provided that institutional units are exercising effective ownership rights over them, that is, are actually in a position to be able to benefit from them. Assets need not be privately owned and could be owned by government units exercising ownership rights on behalf of entire communities.

The atmosphere and the high seas (oceans) are excluded as assets in the SNA because no ownership rights can be exercised for these resources (SNA 1.46). Land as an economic asset may include surface waters of inland water bodies (reservoirs, lakes, rivers, etc.) over which ownership rights can be exercised, but not the seas (SNA 10.175).

## 2.2 SEEA CF

In SEEA, environmental assets are defined as ***the naturally occurring living and non-living components of the Earth, together comprising the bio-physical environment, that may provide benefits to humanity*** (SEEA CF 2.17). In physical terms, the asset boundary of the SEEA Central Framework is broader than the SNA as the ownership criterion does not apply. It basically includes all natural resources of an economic territory that **may** provide resources for use in economic activity (SEEA CF 1.47). Thus, for example, in the SEEA all land is included in the scope for accounting, regardless of its monetary value.

When we apply the definition of environmental assets to the atmosphere and the oceans we conclude that both are included within the environmental asset boundary: both can be considered as 'non-living components of the earth' and both 'may provide benefits to humanity', for example by providing a sink for residuals.

The scope of environmental assets in the SEEA Central Framework is determined through a focus on the individual components that make up the environment. This scope comprises those types of individual components that may provide resources for use in economic activity. Generally, the resources may be harvested, extracted or otherwise moved for direct use in economic production, consumption or accumulation (SEEA CF 5.10). Thus, while the SEEA CF uses a very broad definition for environmental assets, in practice only a limited set of natural resources is taken into account.

The volume of water in the sea is not considered in scope of water resources in the SEEA Central Framework because the stock of water is too large to be meaningful for analytical purposes. The exclusion of the sea in terms of a volume of water resources does not in any way limit the measurement of sea-related individual components such as aquatic resources (including fish stocks on the high seas over which a country has harvesting rights) and mineral and energy resources on or under the seabed. The volume of air in the atmosphere is also not in scope of environmental assets in the Central Framework as it is considered not to be meaningful for analytical purposes (SEEA CF 5.16).

Land in SEEA CF is 'a unique environmental asset that delineates the space in which economic activities and environmental processes take place and within which environmental assets and economic assets are located' (SEEA CF 5.239). the SEEA land accounts encompass areas covered by inland water resources such as rivers and lakes and, in certain applications, the land accounts may be extended to include areas of coastal water and a country's exclusive economic zone (EEZ) (SEEA CF 5.240). The land cover classification as presented in SEEA CF includes a category for Coastal water bodies and intertidal areas. Thus, whereas the seas as a three dimensional water body are excluded from the SEEA CF, coastal water bodies as a two dimensional space are included (in the land accounts).

We thus conclude that the seas and atmosphere are within asset boundary of environmental assets, but are excluded from the measurement scope of the SEEA CF because the associated volumes of water and air are too large to be meaningful for analytical purposes at the country level. With regard to seas and oceans, these are only included as a two dimensional space in the SEEA CF land accounts when located in a countries EEZ.

## 2.3 SEEA EEA: core accounts

SEEA Experimental Ecosystem Accounting (EEA) considers environmental assets from a different perspective than that of the SEEA CF. The focus of SEEA EEA is on the biophysical environment as viewed through the lens of ecosystems in which the various biophysical components (including individual resources) are seen to operate together as a functional unit; thus, ecosystem assets are environmental assets viewed from a systems perspective (SEEA EEA 2.130). Furthermore, in SEEA EEA the extended asset boundary as defined in SEEA CF is used, which means that all ecosystems (i.e. regardless of ownership) are within scope for the (physical) accounts.

In SEEA EEA the focus is on accounting for ecosystem assets (EAs), which are defined as ***distinct spatial areas that form the conceptual base for accounting and the integration of relevant statistics. They represent contiguous areas covered by a specific ecosystem (e.g. a single deciduous forest)*** (SEEA EEA TC). Coastal and marine ecosystems clearly are within the scope of the SEEA EEA. However, the SEEA EEA acknowledges that there are boundary issues with regard to marine ecosystems and the atmosphere (SEEA EEA ). This is the reason why this issue has been put on the research agenda of the SEEA EEA.

We conclude that the seas/ oceans are within scope of the SEEA EEA, but there are some boundary issues still to be resolved. Particularly the status of the atmosphere in an ecosystem accounting context is as yet not clear.

## 2.4 SEEA EEA: carbon account

The carbon account in SEEA EEA is a thematic account. It encompasses measurement of carbon stocks and flows for all parts of the carbon cycle and all carbon pools. Thus, it covers geocarbon, biocarbon, atmospheric carbon, carbon in the oceans and carbon accumulated in the economy (SEEA EEA).

The assets that are considered in the carbon accounts are thus stocks of carbon, which can be further disaggregated based in the reservoir where they can be found, i.e. the biosphere, the geosphere, the hydrosphere (oceans) or the economic sphere. Note that the atmosphere and the oceans thus are not considered as separate assets in the carbon account.

## 3. The nature of ecosystem assets

Ecosystem assets play a key role in the SEEA ecosystem accounting. They are the statistical units for ecosystem accounting, i.e. the entities about which information is sought and about which statistics are ultimately compiled. In the case of ecosystem assets this is information with regard to their extent, condition, the services they provide and their monetary value.

In SEEA EEA (2014) Ecosystem assets were defined as 'spatial areas comprising a combination of biotic and abiotic components and other elements which function together'. In SEEA EEA TR (2017) a slightly different definition has been used, namely 'contiguous areas covered by a specific ecosystem'.

These definitions imply that ecosystem assets are two dimensional units. This is a simplification from reality as ecosystems obviously are three dimensional entities. For statistical and accounting purposes, it is necessary to clearly differentiate ecosystem assets as discrete units. Hence, the boundaries described should be considered a statistical abstraction from an ecological reality.

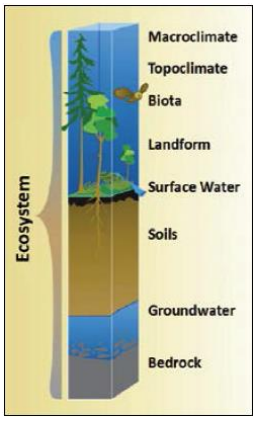
However, the 2 dimensional nature of ecosystem assets also poses some conceptual 'problems' or inconsistencies:

- The typology of the ecosystem assets (as discussion in Discussion paper 1.1) will be based on some specific characteristics which include layered ecological characteristics like vegetation, soil, etc. It is the combination of the three dimensional characteristics of an ecosystem that determine the typology of the asset. In other word, the typology of ecosystem assets will be based on more than simply the 2 dimensional land cover.
- Ecosystem assets as spatial areas are delineated in a two dimensional way, i.e. their extent on a map. However, a relevant question is to how far ecosystem assets extent into the third dimension (i.e. up or down), particularly if we have to consider the atmosphere, geosphere and the oceans.
- Three dimensional characteristics determine the environmental quality of the ecosystem assets as described in the condition account.

**PROPOSAL**: Ecosystem assets are best envisaged as three dimensional columns (see figure below). They include not only biotic components of the biosphere (vegetation, fauna, etc.), but also abiotic components of the geosphere (soil), the hydrosphere (surface water, soil water, groundwater) (*and the atmosphere)*[1]. They are delineated based on a specific spatial area that is covered by an ecosystem that is classified by a certain ecosystem type.

[1] Inclusion of the atmosphere will be discussed in section 3.

**Figure 3.1: The vertical structure of an ecosystem, showing the spatial integration of biological and non-living components.**




Source: Bailey (1996).

The spatial approach is fundamental to SEEA EA and thus should not be changed. However, the definition of ecosystem asset may be modified to make it more clear that they are in fact 3 dimensional units delineated by a 2 dimensional space.

***Possible options.*** Ecosystem assets could be defined as :

- **Contiguous areas comprising a combination of biotic and abiotic components and other elements which function together**. → *a combination of the SEEA EEA and SEEA EEA TR definitions, indicating that the assets also consist of 3 dimensional components…*
- **Ecosystems that are characterized by common ecological characteristics delineated by a specific contiguous area.** → *Depends on the conceptual base to be chosen for the ecosystem type classification.*
- **Contiguous areas that delineate the space where a specific ecosystem is located** → *This definition is related to the definition for land in the SEEA CF, it refers to the 3 dimensional space of the ecosystem.*
- **Contiguous 3D spaces comprising a single ecosystem type. For mapping and accounting purposes the 2D intersection with the earth surface is used.** -> Highlights that on the fundamental level it's 3D but at the practical level it's 2D. Note that we don't define ecosystems here.

## 4. Treatment of the atmosphere in SEEA EA

As discussed section 2, it is not yet clear how the atmosphere should be treated in an ecosystem accounting context. Here we present two options and discuss their advantages and disadvantages.

**Option 1: the atmosphere as a part of ecosystem assets**

Terrestrial ecosystems (including freshwater ecosystems) in principle are all located close to earth surface: the biotic components usually extend from the soil life / plant roots below the surface till the vegetation growing above the surface. The abiotic components are those components that directly interfere with these living components: the soil, the surface/soil water, and also the air from the atmosphere.

The atmosphere/air directly above and within an ecosystem could thus be considered part of the ecosystem asset as one of its abiotic components. Several important ecological processes are based on the interaction with the atmosphere, including photosynthesis, respiration, nitrogen fixation, but also the impact of air pollution on vegetation and fauna. Accordingly, the air could be considered part of the ecosystem, similar as the soil water and soil are also considered to be part of the ecosystem.

A question is how far up the atmosphere can still be considered to be part of the ecosystem asset. Here, it is important to consider till where there still is a relevant interaction with the ecosystem. Clearly, processes in the upper atmosphere (e.g. ozone layer depletion) will not directly impact on the ecosystems.

Advantages:

- This approach is fully consistent with the definition of ecosystem assets as discussed in section 4.2.1.
- Air quality (i.e. indicators for local air pollution) can directly be related to different ecosystems in the condition account.
- There is no need to give the atmosphere any special or separate status as an asset.

Problems/disadvantages

- The supply of a 'carbon storage service' cannot be allocated to the atmosphere as it is not a separate unit.

**Option 2: the atmosphere as a separate unit**

The atmosphere could also be considered as a separate unit in SEEA EEA, i.e. separate from 'other' ecosystem assets. The atmosphere could be seen as one unit, but could also possibly be subdivided into (vertical) subunits.

Advantages:

- Delineation of atmospheric units would allow a more complete accounting to be undertaken for all environmental stocks. For example a complete accounting for carbon and water would allow for recording quantities present in the atmosphere. The concentration of carbon in the atmosphere is known to be an indicator of significant interest with regard to climate change.
- As a separate unit, it will be possible to describe within an accounting framework all the relevant flows between the atmosphere and the economy. This includes ascribing a carbon storage function to the atmosphere.

Problems / disadvantages

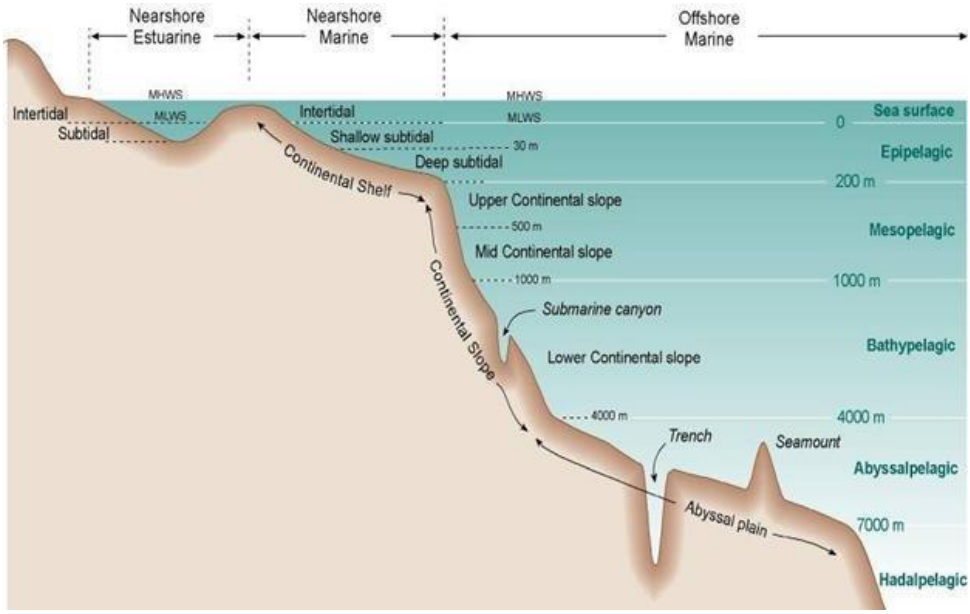
- The atmosphere as a separate unit does not comply with the definition of ecosystem assets (both the definition in SEEA EEA TR or the proposals of a modification as discussed in section 4.2.1). It is difficult to see the atmosphere as a separate ecosystem as it is a geophysical reservoir. Also, the spatial approach does not work for the atmosphere as a separate unit.
- As the atmosphere is not an ecosystem asset, it can also not be included into the classification of ecosystem types.
- In the condition account, indicators for local air pollution cannot be attributed to different ecosystem types.

**Interim conclusion:** How to treat the atmosphere (option 1 or option 2) is open for discussion. However, as a first observation we note that the problems associated with option 2 seem to outweigh that of option 1. Furthermore we would like to note the following:

- A storage function for $CO_2$ in the atmosphere as an ecosystem service, one of the important reasons to go for option 2, is a) still controversial, as the storage of anthropogenic CO2 in the atmosphere contributing to the greenhouse effect can hardly be seen as a (positive) contribution to benefits for our welfare, and b) hard to implement at a national level (there is not a 'national atmosphere' to store $CO_2$, only a global one).
- The issue how to deal with the atmosphere in an ecosystem accounting context also seems to focus on the stocks and flows in the carbon account. The carbon account, now a thematic account in SEEA EEA, seems a kind of hybrid account that partly belongs to the SEEA EEA domain (link to carbon stocks and flows from ecosystem assets) and partly to the SEEA CF domain (carbon as an ; detailed description of physical flows). Maybe when the nature of the carbon account is more clear, also the issues related to the atmosphere are solved.

## 5. Treatment of marine ecosystems

An important difference between terrestrial and marine ecosystems is that marine ecosystems are not concentrated near one surface (i.e. the air-land/water interface), but may extent throughout the water column and the underlying sediment. The question is whether and how the spatial approach of SEEA EA for ecosystem assets can be applied to the marine environment. Basically, there are two options to define ecosystem assets for the marine environment




**Option 1**

Following the spatial approach of SEEA EA, each area of the seas/oceans belongs to one single ecosystem asset. When we follow the reasoning (see section 4.1) that the ecosystem asset is best envisaged as a three dimensional column, an ecosystem for the seas/oceans would include the

entire water column and underlying sediments (plus a part of the overlying atmosphere) delineated by a certain area.

Advantages of this approach are that a) it is fully consistent with the SEEA EA spatial approach, b) each ecosystem asset is mutually exclusive, c) the water column /sediments are described as an integrated unit (which could also be seen as a disadvantage).

**Option 2**

Particularly for deep pelagic waters, ecosystems near the seafloor will be very different from ecosystems within the water column, which in turn will be very different from ecosystems near the surface waters. Accordingly, it then makes more sense to describe the condition, biodiversity and supply of services for different ecosystem assets. For example, a distinction could be made to 'seabed' and 'marine waters' ecosystem assets (see paper Roger Sayre, September 2018). As the water column and the underlying sediment may constitute of different ecosystems, we may discern different ecosystem assets.

Advantages of this approach are that very distinct ecosystems that happen to be at the same geographical coordinates, can be described and monitored separately.

Disadvantages are that a) this approach would be a deviation from the two-dimensional spatial approach of SEEA EA (i.e. each area is assigned to one ecosystem asset), b) it is not clear how the units would delineate vertically, and how can we ensure they are mutually exclusive.

**Interim conclusion:** How to treat the oceans as ecosystem assets (option 1 or option 2) is open for discussion. We would like to make two additional observations that may help the discussion here:

- This issue only seems relevant for the deep part of the oceans (continental slope-abyssal plain). For shallow marine ecosystems, taking the 2 dimensional approach is less problematic. Accordingly, option 2 is only a valid alternative for the deep parts of the oceans. Most national ecosystem accounts will only cover shallow marine/ continental shelf environments.
- Partly, this is a purely conceptual discussion. When we look at the analytical relevance it may turn out that accounting for the deep part of oceans is not that relevant as a) the condition of deep ocean waters and sediments are as yet not or only moderately influenced by human impacts, b) in practice there is no/very little regular monitoring of deep ocean waters/sediments, and thus no data to populate the accounts.

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