Measuring Planet A: Connecting the SEEA Central Framework and the SEEA Experimental Ecosystem Accounting

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1. Introduction

Since their development, the set of accounts described in the SEEA Experimental Ecosystem Accounting (SEEA EEA) have been intended to complement the accounts of the SEEA Central Framework (SEEA CF) to provide a more complete picture of the environment and the connections to the economy and society. This intent is reflected in part in the definition of environmental assets which describes the complementary perspectives where environmental assets can be viewed either in terms of individual assets (timber, fish, water, soil, etc) or in terms of ecosystems.

However, over the past 6-7 years a gap has emerged such that two measurement groups may be considered to exist within the overall SEEA community – a group more familiar with the SEEA CF and a group more familiar with the SEEA EEA. This is perhaps driven by the fact that the ongoing development of ecosystem accounting has entered into measurement and valuation areas not traditionally the focus of SEEA and which are relatively unfamiliar in statistical circles.

Recognising this gap, this paper aims to:

- Outline the accounting principles under which the SEEA CF and SEEA EEA should be seen as coherent and consistent approaches to documenting the link between the economy and the environment, including links to the System of National Accounts (SNA) production boundary and asset boundary
- Describe the areas in which the connection between different accounts should be most commonly identified and where compilation issues arise. These areas include accounting for water, biomass and natural inputs, residual flows, land, environmental expenditure and depletion/degradation.
- Discuss the potential for the SEEA CF and SEEA EEA to contribute in a co-ordinated manner to different policy and analytical issues

A key message from the paper is that the potential benefits from improving connections between SEEA CF and SEEA EEA in the compilation of accounts are large. These benefits can be seen in improved data quality and in the provision of a more complete set of data on the environmental-economic relationship to support decision-making.

The paper will aim to describe the connection both for those more familiar with the SEEA CF, commonly from national statistical offices, and those more familiar with the SEEA EEA, many of whom have not worked in statistical offices. The main focus is on accounting principles and concepts rather than on compilation issues. In that regard, the paper might be seen as a starting point for an ongoing discussion about implementation and application of the SEEA and how to take greatest advantage of the connections between the accounts of the Central Framework and the EEA.

2. Environmental assets in the SEEA

Accounting for environmental assets is a core feature of the SEEA. It is reflected in many parts of the system including in: (i) the understanding that the economy is nested within the environment and is the source of natural inputs and the destination of many residual flows; (ii) the understanding that environmental activities are aimed at maintaining and restoring the physical environment; and (iii) the desire to record the capital cost associated with overuse of environmental assets in standard economic measures such as GDP.

Given this core feature, the measurement of environmental assets is considered right at the beginning of the SEEA Central Framework. The relevant paragraphs are copied below. What is clear is that the text of the SEEA Central Framework is explicit about the breadth of environmental assets to be considered and how these should be framed. Specifically, paragraphs 2.17 and 2.21 recognise environmental assets as being considered from two perspectives – one in terms of individual components (e.g. timber, fish, soil, water, mineral and energy resources, land) and one in terms of ecosystems. This dual perspective approach has been referred to as considering two sides of the same coin. Another way of saying this is that the SEEA recognises that there is only one planet being measured through two complementary perspectives. In short, there is no Planet B and we need to use all our resources collectively to effectively measure Planet A.

Extract from the SEEA Central Framework:

The measurement of environmental assets

2.16 The use of natural inputs by the economy is linked to changes in the stock of environmental assets that generate those inputs. Asset accounts for environmental assets in both physical and monetary terms are an important feature of the SEEA.

2.17 ***Environmental assets are the naturally occurring living and non-living components of the Earth, together constituting the biophysical environment, which may provide benefits to humanity.*** Although they are naturally occurring, many environmental assets are transformed to varying degrees by economic activities. In the SEEA, environmental assets are considered from two perspectives. In the Central Framework, the focus is on individual components of the environment that provide materials and space to all economic activities. Examples include mineral and energy resources, timber resources, water resources and land.

2.18 This focus reflects the material benefits from the direct use of environmental assets as natural inputs for the economy by enterprises and households. However, this focus does not consider the non-material benefits from the indirect use of environmental assets (for example, benefits from ecosystem services such as water purification, storage of carbon and flood mitigation).

2.19 The coverage of individual assets does not extend to the individual elements that are embodied in the various natural and biological resources referred to above. For example, the various soil nutrients are not explicitly considered individual assets.

2.20 A complete description of the measurement of environmental assets in terms of the various individual environmental assets is presented in chapter V.

2.21 The second perspective on environmental assets, which is described in SEEA Experimental Ecosystem Accounting, encompasses the same environmental assets but instead focuses on the interactions between individual environmental assets within ecosystems, and on the broad set of material and non-material benefits that accrue to the economy and other human activity from flows of ecosystem services. Ecosystems are a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.[1] Examples are terrestrial ecosystems (for example, forests and wetlands) and marine ecosystems. Often, there are interactions between different ecosystems at local and global levels.

2.22 For a given ecosystem or group of ecosystems, ecosystem accounting considers the capacity of living components within their non-living environment to work together to generate flows known as ecosystem services. ***Ecosystem services are the contributions of ecosystems to benefits used in economic and other human activity.*** Ecosystem services which are supplied in many ways and vary from ecosystem to ecosystem, may be divided into three groups (a) provisioning services (such as the provision of timber from forests); (b) regulating services (provided, for example, by forests when they act as a sink for carbon); and (c) cultural services (such as the enjoyment provided to visitors to a national park).2 Generally, provisioning services are related to the material benefits of environmental assets, whereas the other types of ecosystem services are related to the non-material benefits of environmental assets.

2.23 Degradation of ecosystems by economic and other human activity may mean that they are not able to generate the same range, quantity or quality of ecosystem services on an ongoing basis. A focus on ecosystems that includes both material and non-material benefits of environmental assets provides a basis for analysing the extent to which economic activity may reduce an ecosystem's capacity to generate ecosystem services.

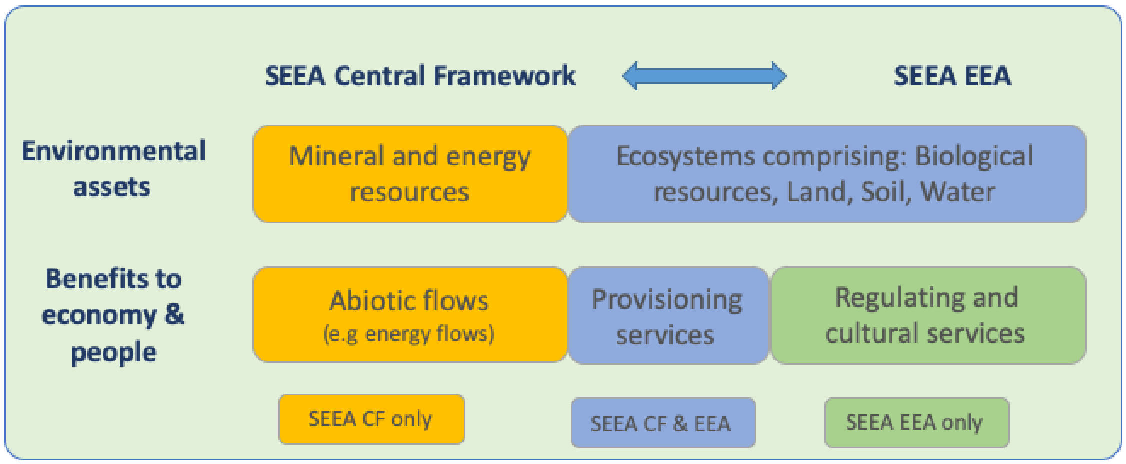
It is also important to recognise that the key features of ecosystem accounting are described in the SEEA Central Framework. While no details are provided, the few paragraphs capture

- the intent to focus on ecosystems of different types and their connections,
- the capacity of these ecosystem to generate ecosystem services,
- the range of ecosystem services going beyond the standard accounting focus on material benefits, and
- the essence of degradation as reflecting the ongoing loss of ecosystem capacity.

[1] Convention on Biological Diversity (2003), Article 2, Use of Terms.
[2] See, for example, Millennium Ecosystem Assessment (2003).

One of the key advantages of using the SEEA CF and SEEA EEA approaches to environmental assets in combination is the richness and holistic nature of the resulting information set. The ecosystem perspective facilitates seeing individual biological resources (timber, fish, etc), water and soil as components of living systems that not only provide inputs to economic production (as captured in the SEEA CF) but also supply a wide range of other services. Further, the link between ecosystems and land supports consideration of these connections between components in specific spatial contexts – i.e. location matters. At the same time, the scope of the SEEA CF captures some environmental assets that are out of scope of ecosystems – e.g. mineral and energy resources – and a range of non-ecosystem service flows – such as energy from renewable sources and the use of space for building and transportation that all need to be understood and placed in context. The links between these components are shown in Figure 1.

Figure 1: Links between the SEEA CF and SEEA EEA concerning environmental assets and their benefits



Some notes are required concerning the boundaries presented here. First, the treatment of water is complex since some water resources (e.g. forms of groundwater) may be considered not to be components of ecosystems and also the abstraction of water may be considered an abiotic flow rather than a provisioning service. It is also noted that some cultural services, e.g. relating to tourism activity, may be inputs to the SNA production boundary although they are not captured in the SEEA CF. Finally, a discussion is underway on the place of the atmosphere in ecosystem accounting – it is currently out of scope of both SEEA CF and SEEA EEA but in a systemic framing of the environment it is more difficult to exclude using the arguments of the SEEA CF (essentially that the volume of air is not a relevant analytical metric).

Sometimes the appreciation of the joint role of the SEEA CF and SEEA EEA is providing a holistic picture of our natural capital can get stopped by a conversation on the different scopes of valuation. Thus, the SEEA CF values of environmental assets are recognised as aligning with the values of the assets (land and natural resources) in the System of National Accounts (SNA). For the SEEA EEA it is recognised that the monetary asset boundary of the SNA is broadened to the extent that ecosystem services (beyond those that are inputs to SNA production) are incorporated in the value of ecosystem assets; i.e. the SNA production boundary is extended thus extended the value of the associated assets. At the same time, the monetary value of some ecosystem components, e.g. biological resources of timber and fish as measured in the SEEA CF, will reflect the value of provisioning services as recorded in the SEEA EEA. Thus while the aggregate values of environmental assets from the SEEA CF and SEEA EEA should not be directly compared there will be elements in both aggregates that should align.

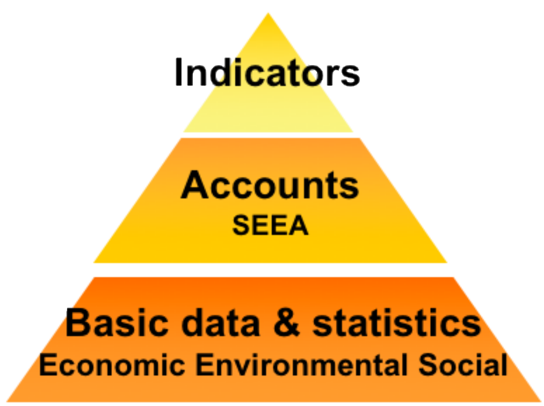
Certainly this distinction is correct but of more importance is that both the SEEA CF and the SEEA EEA have the same scope in biophysical terms which is broader than the SNA. In terms of assessing environmental sustainability and associated thresholds, it is the comprehensiveness of the SEEA in biophysical terms and the clear potential to place a large amount of data concerning individual environmental assets in an overall context that is of highest relevance.

3. Applying an accounting approach

A common underpinning of the SEEA CF and SEEA EEA is the use of national accounting-based compilation approaches. Since aspects of these approaches are different from standard statistical and scientific practice this section summarises some of the key points. This is useful, especially for those not familiar with the compilation of accounts, since it can help to reveal some of the logic behind the methodological choices of the SEEA.

To place accounting frameworks in context it is relevant to consider the information pyramid (Figure 2). This pyramid has as its base a full range of basic statistics and data from various sources including surveys, censuses, scientific measurement and administrative sources. Generally, these data will be collected for various purposes with the use of different measurement scopes, frequencies, definitions and classifications. Each of these data sources will be relevant to analysis or monitoring of specific themes.

Figure 2: Information pyramid



The role of accounting frameworks (at the middle level of the pyramid) is to integrate these data to provide a **single best picture** of a broader concept or set of concepts – for example economic growth or water use. The compiler of accounts uses the definitions contained in the accounting frameworks (such as SEEA) to reconcile and merge data from various sources taking into consideration differences in scope, frequency, definition and classification as appropriate.

Having integrated the data within accounts, indicators (at the top level of the pyramid) can be derived that provide insights into the changes in composition, changes in relationships between stocks and flows, and other features. Indicators can be developed that take advantage of the underlying relationships in the accounts, for example, between stocks and flows, between capital and labour, and between production and consumption. Indicators such as GDP, national saving, national wealth, terms of trade and multi-factor productivity all emerge from a single national accounts framework.

An interesting feature of the information pyramid is that while the frameworks and accounts will remain relatively stable in design and structure over time, there will often be significant variation in the mix of data sets underpinning accounts and also in the indicators that are of primary interest. The variation in data sets should be expected over time, for example through changes in technology, changes in resources for data collection, changes in data collection method. Over time, we should expect improvements in data collection. Changes in indicators should also be expected reflecting changes in policy priorities and new phenomena emerging. In the midst of these changes, accounting frameworks serve to provide a base for comparing over time and among different datasets. Indeed, without a stable framework, the development of indicators and related analysis becomes somewhat of an ongoing dance between competing and changing data sets.

Beyond this context for accounting frameworks, the mindset of national accounting that underpins the design of the SEEA is useful background. Annex 1 describes the approach that national accountants take to compiling a single best picture. It has been drafted with standard economic accounts practice in mind, but direct analogies can be made to working with environmental data in the context of the SEEA. In doing so, it provides an explanation of why the SEEA makes certain choices in its design and more generally describes the anticipated role of accounting frameworks, such as the SNA and the SEEA.

A final area of clarification is required on the role of statistical standards such as the SEEA and SNA and the relationship between them given that they are drafted progressively. In some senses, statistical standards around accounting can be considered as relatively "compatible" in a technology sense in that links between different documents stay largely intact over time. However, each version of a specific statistical standard will incorporate advances in treatments and definitions such that it is intended that the latter document supersedes the former.

Thus, for example, it remains possible to compile measures of GDP based on the SNA 1993 but it is now agreed that the most up to date set of standards is reflected in the SNA 2008. With respect to the SEEA, the SEEA 2012 Central Framework is the first SEEA document having the status of a statistical standard. The SEEA 2012 Experimental Ecosystem Accounting does not yet have the status of a statistical standard but this is the ambition of the current round of revision of the SEEA EEA.

As each statistical standard is progressively developed and refined, it is natural that the connections to other standards are examined in more detail and in some cases, changes may be implied for other standards. However, this is generally only the case at the margin. Thus, improvements in the description of accounting for natural resources in the SEEA CF does not imply that the equivalent material in the SNA 2008 is inappropriate or overwritten. It remains for the custodians of the SNA to consider what developments in the SEEA context might be appropriate in an SNA context. A similar type of relationship is expected between the SEEA EEA and the SEEA CF wherein new insights, for example, about the valuation of environmental assets, that emerge in the development of the revised SEEA EEA, may be considered in a subsequent revision of the SEEA CF. The vast bulk of each standard and its core features will remain in place and appropriate for use in their own right until they are the focus of a specific revision process.

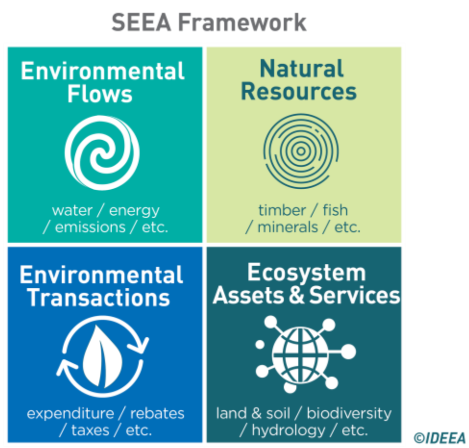
4. Components of the SEEA and their connections

Main components

The main components of the SEEA as described in the SEEA CF and the SEEA Experimental Ecosystem Accounting (SEEA EEA) can be organised into four groups as shown in Figure 3

- environmental flows
- natural resources
- environmental transactions
- ecosystem assets and services, including land and biodiversity

Figure 3: Components of SEEA



The following short descriptions of the four primary components of SEEA hide large amounts of detail but give a sufficient framing to underpin discussion of connections between the accounts.

> **Accounting for environmental flows** involves accounting for physical flows of water, energy, solid waste, air emissions and other substances between the environment and the economy. These accounts are "stand alone", in the sense of each being recorded in the relevant physical unit of measure (e.g. cubic metres of water, joules of energy, tonnes of emissions, etc.) but within each account they are comprehensive seeking to fully apply mass balance principles to the recording of flows.
>
> There is no restriction on the range of physical flows that may be accounted for using the principles of the SEEA Central Framework. Accounting for individual elements such as carbon, nitrogen and phosphorous is quite possible and in theory all elements, substances and products can be tracked. As well, these types of accounts include economy wide-material flow accounts (EW-MFA) where flows of all products are measured in tonnes.
>
> **Accounting for natural resources** sees the environment as comprised of individual resources such as mineral and energy resources, timber, water, fish, etc. The focus is generally on those resources that are inputs to economic activity, i.e. those that can be the focus of harvest and extraction. While in reality each of these resources exists alongside other resources and often within ecosystems more generally, the accounting in this component looks only at an individual resource and describes the opening and closing stock (in monetary and non-monetary terms)

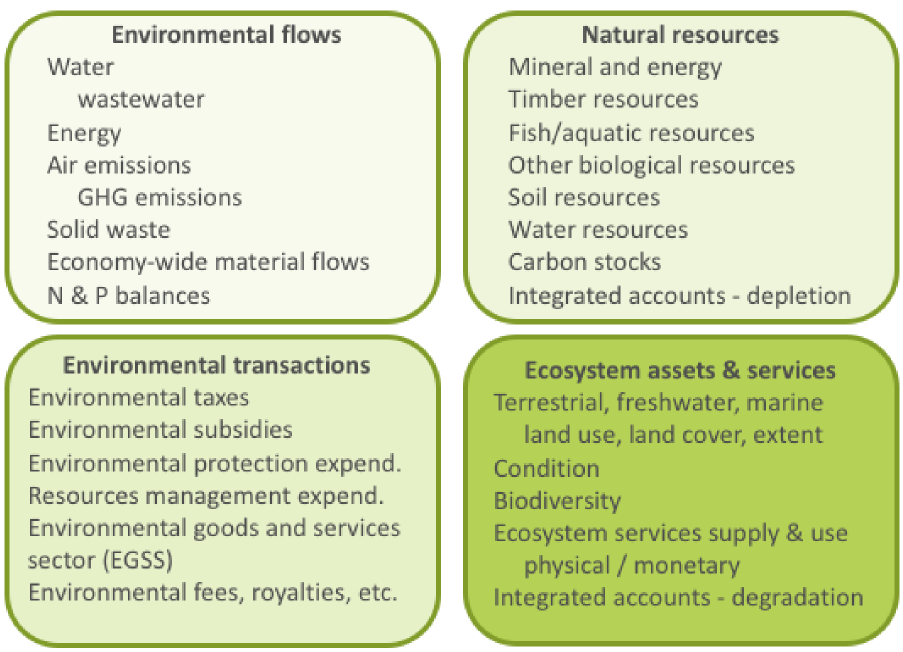
and the additions and reductions between those points in time. This includes the estimation of the depletion of natural resources that can be used to adjust standard measures of GDP.

Accounting for environmental transactions recognises that there are many transactions already recorded in the standard national accounts that are “environmental”, but which are not separately identified in the standard presentations of national accounting data. Examples include environmental taxes and subsidies, environmental protection expenditure and activity in the environmental goods and services sector. The SEEA Central Framework provides standards by which these transactions can be identified and presented to recognise the environmental component of current economic activity.

Accounting for ecosystem assets and services provides a distinct and complementary approach to environmental-economic accounting. In addition to capturing additional environmental aspects (e.g. ecosystem services, biodiversity, vegetation cover, ecosystem condition, etc.) not included in the three other SEEA components, ecosystem accounting provides a platform to integrate most types of environmental-economic accounts when a detailed spatial framing is applied. Further, because of the spatial framing that underpins ecosystem accounting, accounting for land cover and land use as described in the SEEA CF is grouped under this component. Land has unique features which imply that accounting for it can be considered distinct from accounting for natural resources.

Using these four broad groups, Figure 4 provides a high-level “menu” of SEEA accounts. The listed accounts are not intended to provide an exhaustive set of accounts, for example, the figure does not include accounts designed for specific sectors (e.g. agriculture) or specific ecosystem types (e.g. forests).

Figure 4: Main environmental-economic accounts



Coherence between accounts

In understanding the SEEA it is important to recognise that it has not been designed “simply” as a collection of accounts on important environmental themes. Rather, it is envisaged as a **system of**

accounts wherein the data in any given account should be, conceptually at least, consistent and coherent with data in all other accounts. Put differently, all of the individual accounts should work together to provide a **single best picture** of the environment and its relationship to economic activity at a given point/period in time (e.g. a financial year) for a given location of interest (e.g. a country).

By way of example, data on agricultural production, water resources, pollination services and loss of habitat for pollinators – each of which would be captured in different accounts – should tell a logical, internally consistent, narrative. Thus, in a drought, we might expect the accounts to show (i) lower stocks of water resources, (ii) lower volume of agricultural production, (iii) reduced pollination services and (iv) a fall in condition of pollinator habitat. At the same time, it is not the role of accounts to enforce expected relationships, but rather to organise information to assess, ex post, whether such relationships are borne out. The key point is that measurement of each aspect should not be considered as isolated events and editing of data should be such that the potential connections are considered.

In some cases, the coherence in measurement among accounts should be direct and enforced. Thus, for the same spatial area and time period, abstractions of water from the environment recorded in the physical flow account for water should be the same as recorded in the water resources asset account for the reduction in the stock of water. This flow should also be consistent with the flows of ecosystem services recorded related to the provision of water. These logical, accounting connections can and should be used to streamline the use and re-use of data in different accounts. Importantly, the use of the same estimate in more than one account does not represent a double count. A double count can only take place within a single account.

To the extent that different sources of data provide different estimates for the same stock or flow then choices need to be made about the most appropriate data source. It is the requirement for coherence across accounts that places accountants in the position of needing to compare and contrast data sets that may each be of merit. It should be anticipated that this is a common issue in the compilation of EEA for example between estimates of vegetation cover based on earth observation data and estimates based on field studies. Approaches to dealing with these situations are described in more detail in Annex 1.

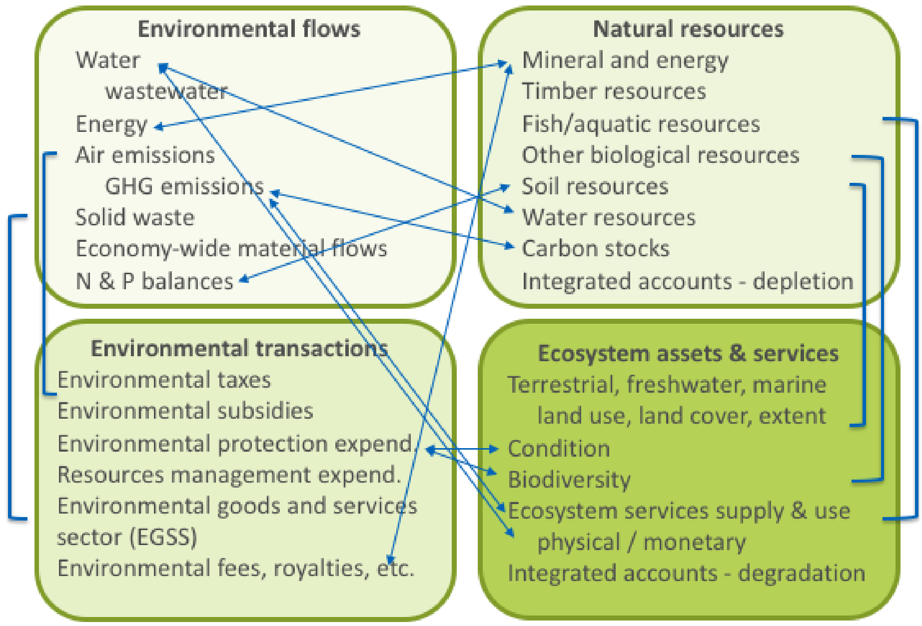
Coherence should also exist across scales in that data for a smaller area should be seen as a subset of data for a larger area that it is situated within. For example, when accounting for Victoria and Australia, the results at the Australian level should be coherent with the results that emerge for Victoria alone. In this case it is not sufficient to simply accept that different methods have been applied at different scales, even if this may be the case. The accounting mindset is that in the measurement of a given stock or flow for a given accounting period, there cannot be two correct answers and some reconciliation is required. The accounting principles make no statement on the direction of reconciliation, i.e. top-down or bottom-up, only that the final estimates are coherent. (Special note is required concerning the measurement of some aspects of biodiversity where certain metrics will be scale dependent. This issue will be considered further in the SEEA EEA revision process.)

Overall, the coherence that is expected across the accounting system should be seen as one of its greatest strengths. It requires experts in measurement to understand and interpret multiple data sets to provide a single best picture to decision makers who would otherwise need to make that judgement themselves, base their decisions on one dataset only, or potentially ignore the information completely due to a lack of clarity on the findings. The lack of a single best picture of environmental stocks and flows and a shared understanding of our collective environmental history is perhaps one of the biggest barriers to reversing the negative environmental trends we are experiencing.

Linking the main environmental-economic accounts

Based on applying the accounting principle of coherence there are many potential relationships among the range of environmental-economic accounts. The figure below shows some of the connections that may be commonly considered. Some short descriptions of four of these connections are provided below. The general message is that while each account should stand alone in terms of adherence to accounting principles, it should also contribute to telling a broader and coherent narrative.

Figure 5: Potential connections among environmental-economic accounts



One area of connections concerns measurement of stocks and flows of carbon, the measurement of GHG emissions and the measurement of ecosystem services, specifically carbon sequestration. It is clear that each of these measurements have value in their own right and are included in different accounts but there is also a strong case for a coherence in measurement for a given spatial area and period of time. A link may also be made to stocks of timber in forests which stored significant volumes of carbon suggesting consistency in measurement between stocks of carbon and stocks of timber would be logical.

A second area concerns measurement of stocks and extraction of renewable natural resources including timber and fish. In this case the changes in stocks should be coherent with the volumes extracted, any associated royalty or resource payments and flows of provisioning services recording in ecosystem services supply and use accounts.

A third example concerns flows of water. There is an established connection in the SEEA CF concerning the entries in the physical flow account for water and the water resources asset account. These entries concerning the stock and flow of water should also be consistent with measures in the ecosystem accounts, for example in terms of the extent of freshwater and flows of ecosystem services such as water provisioning, water purification and water regulation. Put differently, the hydrological modelling that is used to underpin measurement of these ecosystem services should be consistent with the entries recorded in the water resources asset account in terms of stocks, precipitation, evaporation, etc.

A final example concerns the measurement of residual flows such as pollution to water and soil. It would be expected that measures of these residual flows which represent environmental pressures could be aligned with levels of and changes in ecosystem condition. A challenge in making this connection may lie in matching the timing of the residual flows and the change in condition of the affected ecosystem but the general principle holds. Further, measurement of environmental protection expenditure may also be linked to tell a combined picture in terms of whether the response reduces the environmental pressure or increases ecosystem condition. The information set from triangulating these three pieces of information (pressure – state – response) may be of particular interest in developing and monitoring policy.

Beyond linkages between the SEEA CF and SEEA EEA accounts, the common origin of these accounts in the accounting structures of the SNA enables other linkages to be identified. Of perhaps most direct connection concerns measures of primary production (agriculture, forestry and fisheries) where there will be directly associated measurements of production and use of natural capital to be considered. This connection can be further extended in many directions for example with regard to fertiliser use, water use, energy use, pollination services, soil retention, etc. Collectively, data on all of these aspects around primary production should convey a coherent picture of the environmental-economic relationship and in this respect all of the relevant accounts contain data that covers one part of the picture.

Links to the SNA can also be seen in the compilation of sequences of accounts – from production and income accounts to capital accounts and balance sheets. Using the core framing in the SNA, the SEEA CF has designed a complementary sequence of accounts encompassing entries for the depletion of natural resources and the SEEA EEA has proposed sequences of accounts to support entries for ecosystem degradation.

Table 1 below provides a summary of these various accounts connections across the SNA, SEEA CF and SEEA EEA. There is not always a neat match, but the general message should be clear that each of these standards contributes to providing a comprehensive picture of the link between the environment and the economy.

One of the key ways in which links between the various accounts is established and maintained is the use of consistent classifications. From an economic perspective, the key classifications of the SNA are also applied in the SEEA being classifications of industries, sectors and products. This supports making the links between economic and environmental data, e.g. on environmental taxes and expenditures and on flows of water, energy and GHG emissions. Other key classifications that link accounts are classifications of ecosystem types and ecosystem services (both under development and discussion in the SEEA EEA revision process) and the classifications of land cover and use and natural inputs. Establishing stronger connections among these newer SEEA classifications will be important.

As a final note, the types of connections described here and the alignment that is envisaged across accounts can and should also be extended to related accounting systems including SEEA Water, SEEA Agriculture, Forestry and Fisheries, SEEA Energy, Tourism Satellite Accounts.

Table 1: Coverage of SNA, SEEA CF and SEEA EEA on selected stocks and flows

	SNA	SEEA CF	SEEA EEA
ASSETS			
Physcial assets			
Natural resources (componants)			
Abiotic			
Biotic			some in condition account
Renewable energy			
Land		land cover/ land use	ecosystem extent
Ecosystems			
elements (pollutants, carbon etc.)			account, carbon account
Produced capital		Biological resources	Biological resources
Monetary assets			
Natural resources (components)			
Abiotic			
Biotic			as part of ecosystem
Renewable energy			
Land			part monetary value ecosystems may already be included in SNA value
Ecosystems	part monetary value ecosystems may already be included in SNA value		
Produced capital		Biological resources	Biological resources
FLOWS			
Physical flows (material)			
to economy			provisioning final services
within econony			
to environment			Pressure indicators in condition account
within environment			
Non physical flows (non-material)			
to economy			regulating/cultural final ecosystem services
within econony			
Monetary flows			
to economy			services
within econony	all products	environmental goods and services	
Transactions			
Environmental production	all SNA production	by SNA production actvities	By ecosystems assets
Enviromental expenditure (consumption)			
Environmental taxes	all taxes		
Environmental transfers			
Legend	Full coverage		
	Partial coverage		
	No coverage		

5. Considerations in aligning the different accounting framework

Notwithstanding the broad message of design coherence and conceptual alignment described above, there are a few considerations to note that of particular relevance in the compilation of accounts. Since the focus of this paper was intended to be on the conceptual connections, the following considerations should be seen as placeholders requiring further discussion and also seen as an initial list. There are likely other areas of concern that have emerged which should be included in ongoing work.

First, while both the SNA and SEEA CF tend to focus on measurement at national level, compilation of accounting using the SEEA EEA has tended to focus on sub-national areas, e.g. water catchments. Consequently, for coherence and alignment to occur in practice across the accounting frameworks it will be necessary to align spatial scales. For policy and analytical purposes, as discussed in the following section, it may be most relevant to downscale selected SNA and SEEA CF components to match the spatial detail on, for example ecosystem condition and ecosystem services. The challenges involved in measurement at different scales cannot be ignored. Often it might require integrating additional data sources while maintaining consistency across scales. In particular, commonly an understanding of key environmental relationships (e.g. between ecosystem condition and ecosystem service flow) may relate to specific locations and hence applications of results more widely may involve many assumptions, and, at the same time, working at a more aggregate level may provide results that do not reflect the complexities that are present. Nonetheless, given the increasing prominence of using geo-spatial data for statistics and also the understanding that local context is a significant factor, confronting these challenges will be an important and ongoing measurement task. The topic of spatial aggregation and benefit transfer is an active area of discussion in the SEEA EEA revision process.

Second, as noted earlier in the paper, in ecosystem accounting the production boundary is larger relative to the SNA production boundary (which is also applied in the SEEA CF) due to the inclusion of ecosystem services. Understanding the nature of this extension, which also affects the measurement of monetary asset values in ecosystem accounts, is important in ensuring the appropriate alignment between measures in the ecosystem services supply and use accounts and related entries in the SNA and SEEA CF accounts.

A particular point here concerns the link between natural inputs and provisioning services. Following the SEEA CF: "Natural inputs are all physical inputs that are moved from their location in the environment as part of economic production processes or are directly used in production" (SEEA CF 3.45). In general, this definition will encompass the set of provisioning services that reflect the contribution of ecosystems (e.g. agricultural land, forests) to the production of agricultural, forestry, fisheries and similar outputs and the recent discussion on the definition of ecosystem services proposes a treatment aligned with the treatment of natural inputs in the SEEA CF.

Nonetheless, a number of differences in scope must be noted:

- Natural inputs include inputs of mineral and energy resources and soil resources (excavated), and inputs energy from renewable sources (e.g. solar, wind). These are excluded from the scope of ecosystem services and considered as abiotic flows.
- Natural inputs include inputs of timber, aquatic (e.g. fish) and other biological resources only in cases where the production process is uncultivated, i.e. natural.
- Natural inputs include inputs of nutrients, carbon, nitrogen and other elements, generally in terms of inputs to the growth of cultivated biological resources. These physical flows will relate to the recording of provisioning services in cultivated production processes.

- Natural inputs include flows of water to the economy which is commonly included in the scope of ecosystem services but about which there is an ongoing discussion.

In practice, it should be possible to measure provisioning services and natural inputs using similar data sources but there is likely to be further discussion required, for example around the treatment of harvest losses and natural resource residuals.

Third, in the valuation of ecosystem assets, a particular challenge emerges in aligning estimates to the observed values of land recorded in the SNA and SEEA CF. SEEA EEA (paragraph 6.66) discusses the issues which revolve around matching observed market values and values obtained by estimating the net present value of future flows of ecosystem services. This same tension in approaches to valuation of environmental assets can arise with stock or market based value estimates (e.g. of timber) compared to those based on NPV. A long-standing study of this issue concerns the measurement of the value of fish stocks in New Zealand.

Fourth, concerning the measurement of land, there remains a need to clarify the connections between the measurement of land in the SEEA CF, both land cover and land use, and the related measurement of ecosystem extent in the SEEA EEA. All of these concepts are relevant ways to delineate spatial areas within a country or region but further work is needed to show the connections between the concepts and various applications.

Also, in part related to the measurement of land areas, is understanding the relevance of distinguishing cultivated/managed and natural/unmanaged areas. This distinction is present to varying degrees within the classes of land cover, land use and ecosystem types, but the discussion can be confusing when making the link between the type of area and the important SNA distinction between cultivated and natural biological resources and other distinctions of a similar type (e.g. the SEEA CF distinction in treatment between managed and unmanaged landfill). Since a common starting point for compilation is distinguishing the type of area some further clarification on how this can best be achieved would be beneficial and particularly what the links between the SEEA CF and SEEA EEA might be.

Fifth, there will commonly be both a measurement and analytical connection between data on flows of residuals (waste, wastewater, GHG emissions, pollutants to water, etc) as measured in the SEEA CF and the measurement of the condition of ecosystems measured in the SEEA EEA. Residual flows are commonly considered to reflect environmental pressures and in some cases, measurement of the pressure may be considered a reasonable proxy for the measurement of condition. It will be relevant to examine the connections to ensure a coherent picture is presented, also recognising that this is an excellent example of the potential to combine SEEA CF and EEA data to tell a richer picture.

Sixth, also related to measurement of ecosystem condition, useful data on societal responses to environmental issues is provided in the SEEA CF environmental protection and resource management accounts. That is, it might be expected that a relationship exists between the extent of environmental activity and changes in ecosystem condition. Putting aside issues of scale, a compilation question that requires further consideration is whether the existing classes of environmental activity provide sufficient focus on activities for restoring and rehabilitating ecosystems. Any investigation should also consider how to account for the effect of lost/foregone income to producers in relation to undertaking environmental protection and resource management.

6. Policy and analytical applications of coherent accounts

This short section aims to highlight the potential that arises from considering the SEEA CF and the SEEA EEA as an integrated set of accounts. There are three perspectives that can be taken to illustrate the potential, a thematic perspective, an sector/industry perspective, and a spatial area perspective. For a thematic perspective the aim is to select a particular policy theme and then build a complete environmental-economic picture using a suite of accounts. For a sector perspective the aim is to consider an economic sector/industry (e.g. agriculture, tourism) and frame a comprehensive set of environmental and economic data. For a spatial area perspective, the complete picture would pertain to a selected spatial area. Combinations of these three perspectives may also be relevant.

By way of example, for a policy theme of water management at one level it might be considered sufficient to have regularly compiled water resource asset accounts (ideally by catchment) and physical flow accounts for water showing the predominant uses of abstracted water. However, it may be readily considered that a more complete picture would be supplied by integrating data on water quality via ecosystem condition accounts and also bringing into consideration related flows of ecosystem services, for example concerning water purification and recreation. While all of this measurement might be completed in separate silos, the potential advantages from integration of data using the whole SEEA framework, in terms of coherence of data and completeness of describing the relevant system should be clear. It is noted that a spatial perspective on this theme might focus on one or more catchments.

Another example of a policy theme is climate change. Using SEEA CF and SEEA EEA accounts a quite comprehensive picture can be provided around GHG emissions, changes in stocks and flows of carbon by location/ecosystem type, the activities undertaken to mitigate or adapt, the changes in ecosystem condition and biodiversity that are emerging that may be associated with climate change and the linked changes in flows of ecosystem services to various population groups. In short, the SEEA can provide a database to underpin much climate change analysis and support scenario modelling in the same way as the standard national accounts underpin much economic analysis and modelling.

A good example of a sector perspective concerns tourism. In this case, the SEEA CF accounts can provide a strong information base to assess the pressures exerted by tourism activity (e.g. in terms of water use, energy use, solid waste and GHG emissions, land use change) while the SEEA EEA accounts can provide information on changing ecosystem condition, for example, of beaches, coral reefs, waterways, national parks, mountain areas, that are the common focal points for tourism activity. Data on environmental activities can also support understanding of the response of the tourism sector to environmental challenges.

For a spatial perspective, consider the management of protected areas which is a common area of policy interest in maintaining and enhancing biodiversity. Protected areas are spatially discrete areas and hence are an ideal focus for ecosystem accounting in terms of measuring their extent, condition (including local species diversity) and flows of ecosystem services. At the same time, management of protected areas could be enhanced through an understanding of relevant pressures from neighbouring areas (for example by recording residual flows of pollutants and waste) and by linking to measures of environmental protection expenditures and flows of environmental goods and services. While these management benefits from coherent data will arise only if the SEEA CF based data can be compiled for specific areas, the degree of focus provided by attention on specific spatial areas might open pathways to additional data sets that can be organised using the SEEA principles.

7. Conclusion

The aim of this paper was to describe the connections between the accounts of the SEEA CF and the SEEA EEA. The starting point is the definition of environmental assets from the SEEA CF which includes ecosystems. Notwithstanding this common definitional root, somewhat distinct measurement communities around SEEA CF accounts and ecosystem accounting have emerged. While this is understandable given the differences in focus of accounts, data sources and methods that are used, it is hoped that this paper allows compilers to look beyond these differences to see the intention that SEEA is considered provide a complete system for accounting for the relationship between the environment and the economy. This complete system requires data from both the SEEA CF and the SEEA EEA frameworks.

In terms of encouraging greater connection, Section 4 highlighted some areas in which conceptual alignment needs to be clarified but this reflects a natural evolution as the concepts and definitions for ecosystem accounting become established through the SEEA EEA revision process. Section 4 also highlighted the need to align spatial scales of measurement and to consider issues of classification.

It is likely that a key issue will be the resources available to undertake measurement in a more joined up fashion. One pathway forward in this respect might be to consider the policy entry points described in Section 6, particularly concerning policy themes and sectors, and work on designing programs of work that include measurement of both SEEA CF and SEEA EEA accounts that are tailored to the issues and context. It is unlikely that users will care whether the accounts are from the SEEA CF or SEEA EEA – what is more important is that the information set is as comprehensive as possible.

Overall, however, the major challenge will not be about concepts, measurement or resourcing. Rather, the challenge will be the same as the one that has confronted SEEA from its origins – working in collaborative and multi-disciplinary ways. The development of the SEEA EEA over the past 8 years has brought into the SEEA community a wider range of disciplines and institutions. The test remains as to how quickly these additional perspectives can be blended with traditional SEEA national accounting and statistical perspectives to build a more complete environmental-economic measurement community for Planet A.

Annex 1: Key features of a national accounting approach

Introduction

For those not familiar with the way in which national accountants work on measurement issues there are two key aspects that should be understood. First, national accounting approaches commence using data from multiple sources that has already been collected. National accounting is therefore not focused on defining survey questions, determining sample sizes, collecting and processing data, etc. These important tasks are assumed to be completed by experts in specific subject matter areas, relevant methodologists and those in charge of administrative data. In this sense, a national accountant will be one step removed from the source data.

Second, in part as a result of not collecting data, but largely as a result of the underpinning conceptual framework, national accountants work “from the outside in”. National accounting is not a “bottom up” measurement approach whereby aggregates are formed by summing available data from a single survey or other data source. Rather, most effort goes into ensuring that the estimates that are compiled appropriately reflect the target concept, for example, economic growth or household consumption. Generally, it will be the case that no single data source can fully encapsulate a single concept and hence the role of the national accountant is to meld, integrate and otherwise combine data from multiple sources to estimate the concept as best as possible.

Further, it is not sufficient to obtain the best estimate of each concept in isolation. Rather the measurement of each concept must be considered in the context of the measurement of other concepts following national accounts identities. Thus, for example, total supply and total use of each product must align. Ultimately it is the ambition to produce, at a single point in time, the single best picture of the concepts in scope of the national accounts framework. This cannot be achieved by relying on a bottom up strategy where the micro builds neatly to the macro. Instead, a top down or working from the outside in approach must be one part of the process.

Building on these two key aspects, there are some related national accounting compilation principles that should be recognised.

> *The maintenance of time series is fundamental.* It is not sufficient for each data point to stand alone in time and, even though data sources may change, the accounts must continue to estimate meaningful change over time.
>
> *Prices, quantities (volumes) and values are all relevant.* While the vast bulk of the national accounts framework is presented in terms of relationships in value terms (i.e. in terms of the actual monetary amounts transacted); the most significant proportion of resources on compiling national accounts are targeted at decomposing the changes in value between changes in prices and changes in underlying volumes.
>
> *The need for revisions.* Given their scope, there is always new information that might be considered or new methods that might be adopted to refine the single best picture. National accounting thus works by ensuring the regular release of the best picture in the knowledge that it may be revised in due course when additional information comes to hand.
>
> *Accounting is iterative.* The process of integrating data for accounting is not a single, one-off process. Each time a set of accounts is compiled, different integration issues will arise and will

generally only be resolved through attempting integration, understanding the reasons for imbalances, and implementing possible solutions. Gradually, a single best picture emerges. Ideally, resolving these integration issues is a task that involves both accountants and data supplying areas. Such joint resolution is an important aspect in mainstreaming different data as part of an overall picture.

One overall consequence of a national accounting approach to compilation is that comparability among different estimates is **not** assessed primarily on the basis of method. In the first instance, comparability is based on the extent to which different estimates accurately reflect the target concept. Indeed, since each national accountant will be faced with the integration of different source data, a focus on comparability of methods is likely not a helpful starting point (although it must be accepted that not all methods will produce estimates of equal quality).

One benefit of a focus on concepts is that countries will tend to focus their resources on measuring those aspects within the accounting framework that are of most relevance to them. For example, in a country in which agriculture is a dominant activity, resources should be allocated to measurement of this activity. In a different economic structure, for example a country with a large finance sector, the balance of resources and the choice of data and methods will and should be different. Since economic structures changes over time, methods will also need to adapt. The development of services statistics and associated measurement methods over the past 25 years is a good example of this evolution in compilation approaches even as the underlying concepts remain stable.

Applying the national accounting approach to environmental-economic accounting

Most measurement activity aims to generate databases pertaining to a single theme or topic and to provide the best estimates based on the selected methods and resources available. While this may well, and should, involve comparison with other datasets as part of editing, it generally does not involve full integration and reconciliation with other datasets.

A national accountant, on the other hand, is not compiling this type of dataset but rather is seeking to undertake the integration and reconciliation. In many respects this is a role that must, at some point, be undertaken by a data user, analyst or decision maker. That is, at some point interpretations and judgements are needed concerning data from different sources that may suggest different trends. Within the scope of macro-economic analysis, national accountants make such judgements about relative data quality and coherence using the rigour of the national accounting framework. The alternative would be a situation where each economic analyst made their own judgements possibly using varying definitions of economic aggregates and measurement scope.

The application of a national accounting approach for environmental-economic accounting extends this national accounting compilation approach to biophysical and scientific data. That is, within environmental-economic accounting the ambition is to integrate the various sources of information on ecosystem condition, ecosystem services, economic production and consumption, to present the single best picture.

One consequence is that for environmental-economic accounting it is necessary, but not sufficient, to have for example data for a particular ecosystem type or for a selected set of ecosystem services. In addition, effort must be made to obtain information that permits assessment of the whole area of interest and full scope of supply of ecosystem services. Certainly, it would be relevant to place most resources into measuring those ecosystems and their services that are considered most relevant and significant, but this should not detract from the ambition to measure the whole.

In putting national accounts estimates together it means that data that may be regarded as of good quality are adjusted to ensure an integrated picture. As well, since the emphasis is on the measurement of a defined framework, some data sources may not be used, whatever their quality, since they are not defined following the required concepts.

While these statements are somewhat stark, in practice, a national accounts approach is very reluctant to ignore any information. Rather, efforts are generally made to examine all relevant data and, where necessary, make adjustments to permit integration.

Principles and tools of national accounting

The focus here is on the main principles and tools that national accountants apply to ensure coherence in the integration of data from multiple sources. The following paragraphs present a brief description of the relevant principles. An extensive discussion of the principles is contained in the SNA 2008 and an extended overview is provided in SEEA Central Framework.

Accounting identities. The accounting system relies on a number of identities – that is, expressions of relationships between different variables. There are two relationships of particular importance in ecosystem accounting. First, there is the supply and use identity in which the supply of a product (or, in this case, an ecosystem service) must balance with the use of that same product. This identity applies in both physical and monetary terms. Often information on the supply and use of a product will be from multiple sources and hence this identity provides a means by which data can be reconciled.

Second, there is the relationship between balance sheets and changes in assets. This identity is that the opening stock plus additions to stock less reductions in stock must equal the closing stock. Again, this identity applies in both physical and monetary terms. Without this identity there would be no particular reason to ensure that observed changes in ecosystem assets (e.g. through natural growth or extraction) aligned with the series of point-in-time estimates of ecosystem condition that underpin the balance sheets.

Frequency of recording. In order to provide a single best picture across multiple data sources it is essential that there is a common reference point referred to in accounting terms as the accounting period. Generally, it is recommended that the accounting period used across a set of SEEA based accounts is one year. This supports alignment with economic data that are usually compiled on this periodicity. Flows are measured such that all activity that takes place during the selected accounting period is recorded. Stocks are measured at the opening and closing dates of the accounting period.

Commonly, different data sources will have different reference periods and thus adjustments will be required to allow appropriate integration. For example, flows may cover a date range that is not aligned with the selected accounting period and/or stock information will relate to a non-opening or closing period date. Where adjustments are made these should be made explicit or if no adjustments are made then the implicit assumptions should be described.

For the measurement of some ecosystem characteristics and services the use of an annual frequency may not be ideal. For example, at larger scales changes in ecosystem extent may only be detectable over periods of three to five years. In the other direction, measurement of changes in water resources may require sub-annual data to detect seasonal variation. As appropriate it is relevant to record and present specific data using these alternative frequencies such that decision making and analysis can be best supported. At the same time, a single frequency is required for the integration of all data, including economic data, and it is for this purpose that annual recording is proposed. This frequency also ensures a regular presentation of ecosystem accounting data to decision makers and supports the mainstreaming of environmental information that is a core ambition of the SEEA.

In addition to these key principles there are a few common tools and methods that national accounts apply. These are

Benchmarking, interpolation and extrapolation. Among the range of different data sources there will usually be a particularly high quality source in terms of coverage and quality. Commonly such a source will provide a benchmark estimate at a point in time or for a given accounting period. Using this information as a base, it is then common to use indicators to extrapolate this information to provide more up to date estimates (a process known as "nowcasting") and also to interpolate between benchmarks, for example in cases where the best data are collected every 3 years but annual estimates are required for accounting purposes. Generally, these techniques are applied to generate the initial estimates for a particular variable and may be subsequently adjusted through the balancing and integration process.

In some respects, these types of benchmarking and interpolation/extrapolation techniques may be regarded as a form of modelling. The extent to which this is the case will depend on the sophistication of the technique that is used. Generally, regressions and the like are not utilised since maintaining these models across the full extent of a national accounts framework would be very resource intensive. Further, since the estimates for an individual time series are eventually integrated within a series of accounting identities it may be difficult to rationalise the statistical advantage of applying detailed modelling approaches for individual series.

Modelling. Where modelling does become more in evidence is when there is a clear shortage of data for particular variables – i.e. there are no direct estimates or benchmarks that can be used to provide a starting point. In this case, modelling may be required. An example in standard national accounts is the estimation of consumption of fixed capital (depreciation) which are commonly derived using the so-called perpetual inventory model (PIM) that requires estimates of capital formation and assumptions regarding asset lives and depreciation rates.

In the context of ecosystem accounting, the spatial detail required is likely to considerably increase the need for modelling and this will be new ground for many national accountants. Chapter 5 of the Technical Recommendations considers the role of biophysical modelling in ecosystem accounting and the general issue of spatial imputation where information estimated in one location is applied in other locations. Such modelling and imputation may be relevant in the measurement of ecosystem extent, ecosystem condition and ecosystem services. While these may not be traditional "sources" of information for national accounts type work, there is no particular reason that such modelled data cannot be directly incorporated. It remains the task of the accountant to integrate all available data as best as possible. At the same time, a balance must be found concerning the proportion of data that are modelled within the overall dataset. Excessive reliance on modelled rather than directly collected data may raise questions about the accuracy of the information.

A general issue that crosses all of the discussion through this section is that of data quality. Unlike many of the source data that feed into the national accounts it is not usually possible to give a precise estimate of common measures of data quality such as standard errors. The melding and synthesis of multiple data sources makes this task relatively intractable. In the same context, it is challenging to measure the significance of the application of accounting principles on data quality. While clearly these principles lead to coherence in the final data – it is often unclear how much adjustment might have been required in order for the coherence to be enforced.

Ultimately it will often be the case that accounts are considered of a relatively good quality if the picture that they present is broadly considered a reasonably accurate one. This may emerge from consideration of

- How well the accounts reflect and incorporate data that are considered to be of high quality.
- Commentary by accountants as to the extent of adjustment required (noting that in a number of situations accounts may be left unbalanced and the size of the discrepancy may be a measure of quality).
- The size of revisions to the estimates. A consistent pattern of large revisions to initial estimates either up or down would give an indication as to the relative quality of the source and methods.
- The usefulness of the data from the accounts to users. At the end of the day if the data from the accounts do not support meaningful decision making or analysis then the quality of the accounts must be questioned.

A final area concerns the treatment of uncertainty in accounting contexts. SEEA EEA Chapter 5 provides an overview of several areas of uncertainty that may affect information used in ecosystem accounting. By its nature, accounting aims to provide a single best picture and, in this context, it would seem to ignore issues of uncertainty. Three points should be noted. First, to the extent that the inputs into an accounting exercise are subject to uncertainty then this should be taken into consideration in the compilation of the accounts themselves. Ideally, degrees of concern about the data would be the subject of description in the reporting of accounting outputs. The same holds true for any assumptions that are applied in the construction of accounting estimates – for example in terms of estimating future flows of ecosystem services in net present value calculations.

Second, while not generally undertaken, it would be plausible to consider publishing some ecosystem accounting aggregates within sensitivity bounds. The challenge of course is to ensure that a balance in the accounting identities would be meaningfully maintained but with further consideration of how uncertainty can be usefully reflected within an accounting context would be welcome.

Third, accounting does not provide a model for forecasting future changes in systems. The national accounts organise information about the composition and changes in economic activity but do not purport to provide future estimates of economic growth. Economic models perform this role, generally using time series of national accounts data.

In the same way, environmental-economic accounting is not designed to provide a model of how the environment behaves that can be used to forecast environmental outcomes. Rather, it records, ex post, measures of changes in ecosystem condition and flows of ecosystem services. How this information might be combined to support estimates of future flows or changes in condition is a separate issue and likely subject to considerable uncertainties. This distinction between creating a structured set of information on past events and modelling future states is often not made in scientific discourse and usually forgotten by economists. However, it is fundamental to understanding the role that accounting may be able to play in supporting the mainstreaming of environmental information into decision making.

Although the national accounts do not provide forecasts, it is true that estimates of future trends are included in the derivation of some national accounting estimates. An example is the use of information on future flows of ecosystem services in the measurement of ecosystem capacity and ecosystem asset net present values. While it is true that net present values require information on future flows, ideally this information should be obtained from specific data sources, models and expert opinion. Where such inputs are not available, national accountants will commonly make assumptions about the future flows (usually based on past history) such that a net present value can be estimated. However, this is quite different from concluding that the national accounts framework provides a model that should be used for forecasting.

TEM discussions on thematic accounts

Connections between ecosystem accounts

There are a number of SEEA EEA ecosystem accounts each with connections to the other and to other accounts including the SEEA Central Framework and the SNA. This discussion was aimed at clarifying the way in which the revised SEEA EEA should describe these connections, with particular focus on the connections to thematic accounts, i.e. those sets of accounts focused on specific themes of policy or analytical interest.

Discussion started with consideration of the diagram used in the SEEA EEA to show the links among the core ecosystem accounts. While broadly OK, it was suggested that the numbers of accounts be removed to reduce implications of dependency, that the dotted line surrounding condition and ecosystem service supply be removed and the distinction between physical and monetary be better highlighted.

In terms of core ecosystem accounts it was agreed that extent and condition accounts should be kept as distinct accounts. Integration with the SEEA Central Framework and the SNA was considered important and primarily a challenge of linking the sub-national, spatial approach of the SEEA EEA with the national level focus of the other accounts. For example, compiling water and air pollution accounts at catchment or finer spatial resolutions. One issue to be addressed is the link between ecosystem services and flows of natural inputs as defined in the SEEA Central Framework.

Most discussion focused on the design and role of thematic accounts. The general conclusions were:

- That discussion of thematic accounts would be an important part of the revised SEEA EEA with a focus on demonstrating how the ecosystem accounting framework can support a focus on specific areas
- In this context, it was clear that for some themes it would be relevant to include accounts on pressures (e.g. pollution, waste, emissions) following the design of accounts in the SEEA Central Framework. Links might be made to the DPSIR framework.
- It was suggested that general guidance for the design of thematic accounts could be developed along with specific examples such as for oceans, protected areas, wetlands, forests.
- Separate chapters will be required on accounting for stocks and flows of carbon and accounting for biodiversity
- Given that land and water accounts are discussed in the SEEA Central Framework, the exact content required for the revised SEEA EEA was less clear, perhaps a focus only from a data source perspective is required.

A short discussion on the relevance of a capacity account concluded that capacity is an important component of the ecosystem accounting model but the precise nature of a capacity account required further consideration, including whether it might be considered more of an analytical step. Of importance is understanding the link to the condition account, the question of the links to intrinsic and instrumental values, and whether a capacity account should be developed in both physical and monetary terms.