The valuation of ecosystem services and assets for SEEA ecosystem accounting

Background paper on SEEA EEA approach to valuation prepared for the BfN/UNSD workshop on ecosystem valuation: Bonn, Germany – April 2018

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1. Introduction

The aim of this background paper is to provide a context for a national accounting-based approach to the valuation of ecosystem services and assets. In doing so, it is hoped that this material can support an informed discussion on how the variety of approaches to environmental valuation that have been developed may be best applied for the implementation of the System of Environmental-Economic Accounting Experimental Ecosystem Accounting (SEEA EEA) framework.

The workshop on the valuation of ecosystem services and assets in Bonn will be the first large workshop contributing to the revision process of the SEEA EEA and focuses on a critical issue for ecosystem accounting, monetary valuation. It is intended that the outcomes from this workshop become a starting point for further discussion and engagement, and will feed into the SEEA EEA revision process.

The outline is as follows. Section 2 provides a brief overview of key accounting principles for valuation in the System of National Accounts (SNA) (European Commission, et al 2009). Section 3 describes primary issues that have been identified with respect to valuation in the context of ecosystem accounting. Throughout the paper some references are made for further reading.

2. Key accounting principles for valuation

Introduction

Ecosystem accounting is an application of national accounting principles established for the measurement of the economy to the measurement of ecosystems and biodiversity. The SEEA ecosystem accounting framework is reflected in a series of relationships between various stocks and flows which are defined in such a way as to allow data on ecosystems and biodiversity to be integrated directly with economic data contained in the standard national economic accounts. Ecosystem accounts thus support the organisation of environmental and economic data in a manner that encourages and supports viewing the relationship between the environment and the economy in an integrated and systemic way.

Annex 1 provides an excerpt from the recently released SEEA EEA Technical Recommendations (UNSD, 2017) that summarises the key components of the ecosystem accounting framework and the links between them. In practice, ecosystem accounting involves four key steps:

i. Delineating a given territory (e.g. a country) into distinct ecosystem units each classified by ecosystem type (e.g. forest, wetland, grassland)
ii. Measuring the extent (size) and condition of each ecosystem unit

iii. Measuring the flow of ecosystem services from each ecosystem unit
iv. Recognising that each ecosystem unit can be considered an asset which has a capacity to generate a stream of ecosystem services into the future depending on its extent and condition.

Valuation enters the framework of ecosystem accounting when there is a need for estimates of ecosystem services or ecosystem assets in monetary terms for policy or analytical purposes. Thus, the framework itself and the relationships that it embodies does not require monetary valuation. Further, while the focus of valuation in this paper is on valuation in monetary terms, the ecosystem accounting framework can also support discussion of non-monetary valuation building on the common focus of the SEEA on biophysical data.

Aside from this very quick introduction, the discussion in this section is not designed to summarise the ecosystem accounting framework described in the SEEA EEA. For a summary of the technical aspects of the SEEA EEA please refer to the SEEA EEA Technical Recommendations Chapter 2 released in December 2017.

The focus in this section is on the logic underpinning a national accounts-based approach to valuation of ecosystem assets and services in monetary terms. It is clear that accounting-based approaches to valuation differ from other, primarily economic, approaches to the valuation of environmental stocks and flows. Developing a common understanding of these differences and resolving them is the key focus of the Bonn workshop.

Transactions and units

Fundamentally, accounting involves the recording of transactions between distinct (separable) units. In national accounting, the units are individual businesses, households, government agencies and other institutions. For national accounting of a country, the set of units that defines an economy is limited to those units considered resident of that country. In corporate accounting, the overall focus of accounting will be on an individual business and its interactions with other businesses and economic units, but commonly there will be assessment of different operational units within a business (e.g. cost and profits centres) to support more detailed understanding of business performance. Accounting principles for recording transactions can be applied to any number of units and any number of transactions.

The logic of the ecosystem accounting framework is that national accounting principles are applied to an extended set of units including both the economic units just described and the ecosystem units obtained through the delineation of the country into distinct spatial areas.

With this broader set of units in place, the question then turns to the types of transactions that might be recorded. Most commonly in national accounts, focus is on monetary transactions where there are observed prices for the exchanges of goods, services and assets between economic units. However, the national accounts also incorporate treatments for non-monetary transactions, such as health services provided free of charge by governments to households.

National accounting also allows for imputed transactions in cases where an explicit exchange between two units is not observed but where there is an implicit exchange that is analytically useful to record as a transaction. Examples of imputed transactions include the case where people who own their own home are recorded as paying housing rent to themselves. Here while no actual payment takes place a flow of own-account housing services is recorded reflecting a transaction between the household as a producing unit and the household as a consumer.

In the ecosystem accounting framework, the transactions of relevance are the flows of ecosystem services either between ecosystem units and economic units (so-called final ecosystem services) or between ecosystem units (so-called intermediate ecosystem services). Since at larger scales the transactions between ecosystem units will "net out" in an accounting sense, the primary focus of ecosystem accounting is on the flows of final ecosystem services that are generated/supplied by ecosystem units and received by economic units, including households. However, some key intermediate services, such as pollination, may be of particular interest in some contexts.

The set of transactions (including monetary, non-monetary and imputed) in goods and services recorded in the standard economic accounts is defined by the production boundary. This boundary establishes the concept of production requiring the blending of capital and labour to produce outputs. In the standard economic accounts described in the System of National Accounts (SNA), the concept of production excludes outputs arising from natural processes which do not involve human inputs.

The ecosystem accounting framework incorporates ecosystem services by extending the concept of production to include natural processes. The result is that ecosystem services become additional outputs within the national accounting system alongside the standard/SNA set of goods and services. Having been recognised as outputs produced by ecosystem units (natural capital), these ecosystem services can now be recorded as being transacted within the accounting system.

In some cases, the transactions in ecosystem services will provide direct inputs to the production of goods and services (outputs) currently recorded within the SNA production boundary. These outputs are referred to in the SEEA EEA as *SNA benefits*. By way of example, timber growth (an ecosystem service) will be an input to the production of felled timber and wood products (SNA benefits). In other cases, the ecosystem services will be inputs to *non-SNA benefits*, i.e. outputs that are not within the current SNA production boundary. For example, water regulating services are inputs to the non-SNA benefit of flood protection.

A fundamental point in understanding the ecosystem accounting framework is that it aims to treat ecosystem services and assets in a manner that is as analogous as possible to the treatment of produced assets and standard goods and services as described in the SNA. This ambition of parallel treatment is not seamless, but it has proved robust and possible. The potential benefits from a parallel treatment of produced and ecosystem assets should be clear in terms of the potential to reflect the environment and the economy as a single, integrated system. The challenge is to understand what assumptions and limitations may be implied and the extent to which any issues are material from a decision-making perspective.

Defining ecosystem services for valuation purposes

The literature highlights that there are a wide range of ecosystem services that can be described. To date, the SEEA EEA has used the general framing of provisioning, regulating and cultural services reflecting the Millennium Ecosystem Assessment (MA, 2005) and the Common International Classification of Ecosystem Services (CICES). This broad framing has helped to make it clear that ecosystem accounting intends to incorporate all types of ecosystem services not only those that may be more directly related to current measures of economic activity.

However, it is also the case that it has been challenging to align the framing of ecosystem services reflected in the MA with the concept of transactions between units outlined above. In short, in the MA ecosystem services are defined from the perspective of the beneficiaries or receivers of the services (i.e. what benefits do people obtain from the ecosystems) while

from an accounting perspective, ecosystem services are considered from a production or supply perspective (i.e. what is the ecosystem producing that is supplied to another unit).

This distinction is particularly evident in the comparison of the definition of ecosystem services used in the MA in which ecosystem services **are** the benefits, and the definition of ecosystem services in the SEEA EEA in which ecosystem services **contribute to** the benefits. The SEEA EEA definition aligns with the literature from Boyd and Banzhaf, Haines-Young and Potschin and others using variants of the cascade model to explain the relationship between ecosystems and people. Unfortunately, in the valuation literature the explicit recognition of the difference between services and benefits is less common and hence there is often less focus on clearly specifying the flow that is the target of valuation.

Where there is a tangible exchange of materials (wood, fish, water) the definition of the ecosystem service, the distinction from the benefit, and the description of the ecosystem services by both the supplier (i.e. the ecosystem unit) and the user can be readily aligned. However, when the transaction is more intangible or where the benefit is received by a community rather than an individual, it can be much harder to reach a conclusive description of what has been transacted and hence what is the ecosystem service and what is the benefit.

A fundamental research issue for the SEEA EEA revision process is therefore determining the appropriate description of ecosystem services consistent with the national accounting approach of transactions and production. The resulting typologies and classes of ecosystem services may be categorized into provisioning, regulating and cultural services but the precise descriptions of the output measured will vary for individual services.

Further, in national accounting each transaction will have a value that can be decomposed into a price and a volume/quantity component. To support improved descriptions of ecosystem services it will also then be important to understand the measurement units that are being used to reflect the volume or quantity component. For example, for provisioning services the quantity is likely to be measured in tonnes of timber or fish. However, for other services, such as water purification, the quantification in volume terms of the service being transacted may be far less clear even though there is general acceptance of the value of the service.

This paper does not attempt to resolve these issues it is just noted that a discussion and resolution of valuation of ecosystem services will require a common understanding of what is being valued. Too often in the literature there has not been an active discussion of this issue and as a result there is a distinct lack of comparability across different studies.

The valuation question for accounting

Building on the foregoing discussion, it should be clear that the interest in valuation for accounting purposes is on the exchange value of the ecosystem service that is being transacted between an ecosystem unit and an economic unit (or between ecosystem units in the case of intermediate services). Exchange values are those values that reflect the price at which ecosystem services and ecosystem assets would be exchanged between buyer and seller if a market existed.

The concept of an exchange value reflecting a price between a willing seller and a willing buyer is at the heart of national accounting and is applied in ecosystem accounting to ensure that the values for ecosystem services can be directly aggregated and compared to values contained in current national accounting, and indeed corporate accounting, systems. The published measures of economic and financial performance are all based on exchange values and exchange values are required in order to correctly integrate ecosystem values into these systems.

This is not to suggest that other valuation concepts are not relevant for decision making or are somehow incorrect. Indeed, there is significant advantage in understanding the implications for the change in welfare for a particular consumer or producer as a result of changing circumstance. The perception from the national accounting and SEEA communities on environmental valuation in general and ecosystem services valuation in particular, is that it has been aimed largely at understanding changes in welfare arising from changes in the supply of ecosystem services.

Unfortunately, in the past these "welfare values" and the associated valuation methods have been poorly characterised and understood by the national accounting community and many potential approaches to support the estimation of exchange values have been ignored. Recent efforts in the context of the SEEA EEA has aimed to unbundle the range of misconceptions that have arisen about exchange and welfare valuations and to assess how the decades of experience in environmental valuation can be best used in a national accounting context. The Bonn workshop is the next opportunity to continue to build the conceptual and practical bridges.

Three further points are worth highlighting to provide further context for the discussion in Bonn:

- Valuation for accounting takes no position on whether the transaction is good or bad in a welfare context. By way of analogy, the production of 100€ worth of cigarettes is treated equivalently to the production of 100€ worth of apples.
- The term "market prices" is commonly used to represent the concept of exchange values in national accounting. This term can be misleading in two ways:
    - First, it may be implied that national accounting only includes prices obtained from markets or where there are observable exchanges between buyers and sellers. In fact, as noted above, accounting includes market, non-market and imputed transactions.
    - Second, it may be implied that exchange values are estimated on the basis of pure/free market assumptions such as free entry and exit, complete information, etc. In fact, this is quite incorrect and exchange values in accounting reflect observed values and prices ('ex post') that are a function of many different types of institutional arrangements from low to heavily regulated, or from monopolies to open markets. The SNA records the observed value of economic output irrespective of the actual market mechanism in place.[1]

To support further understanding of the target of valuation for accounting purposes, Annex 2 provides the Executive Summary of the recent World Bank report by Atkinson and Obst. This report aimed to build understanding between the accounting and environmental economic communities by looking at areas of misunderstanding and potential connection.

SNA approaches for valuing non-monetary transactions

Since the SNA set of transactions goes beyond those reflected in monetary transactions, the SNA provides guidance on valuation for non-monetary transactions and imputed transactions.

[1] It may be of substantial analytical interest to estimate the difference between the observed price under existing institutional arrangements and what the price for the same transaction might be under an alternative set of institutional arrangements. However, it is not the task of accounts, at least in cases where observed prices exist, to estimate prices under alternative institutional arrangements.

SEEA EEA section 5.4.3 provides a summary of this guidance. In short, the approaches are to use either

- the prices of similar items being traded (market price equivalents); or
- the costs of production (generally including a return on produced capital)

Unfortunately, while these approaches are well accepted within the national accounts community and routinely applied in many situations (e.g. for measuring the output of government activities and imputed rent on owner-occupied housing), the approaches are largely taken for granted within the national accounts community without clear articulation of the underlying economic assumptions and associated implications.[2]

This gap in the national accounts articulation of economic theory in relation to the valuation of non-monetary transactions is particularly evident when trying to engage with practising environmental and ecological economists who will commonly start from a set of valuation assumptions. The description of the economic assumptions required for exchange values, including the relevant institutional assumptions, is a fundamental requirement for ecosystem accounting in monetary terms.

The treatment and valuation of ecosystem assets

The approach described in the SEEA EEA to account for ecosystem assets in monetary terms is equivalent to the approach used in the SNA to account for produced assets such as machines, buildings, etc. (In turn the SNA approach reflects the long-standing capital and multi-factor productivity measurement approaches of Solow, Jorgenson, et al.) Thus, the estimated value of an ecosystem asset at any point in time is the net present value (NPV) of the future stream of income arising from the production of ecosystem services that are expected to be transacted in the future. In the context of ecosystem assets this implies aggregating across the bundle of ecosystem services that an individual ecosystem asset will generate.

Following this approach, the estimate of ecosystem degradation in monetary terms is equal to the loss in value of an ecosystem asset (reflected in losses of future flows of services) that arises due to economic and other human activity. Following SEEA principles, for ecosystem degradation to be recorded there must be an associated decline in condition (in physical terms) of the ecosystem asset. That is, losses in the value of the asset that are not due to declines in condition are recorded elsewhere in the accounting system.

The use of an NPV based approach is conceptually sound but, of course, raises many questions including the choice of discount rate, the expected asset life, the expected pattern of future flows, the estimated values of those future flows (especially in light of scarcity and boundary constraints), etc. Answers to a number of these questions are likely to be of interest whether or not an NPV based valuation is attempted. For example, to assess questions of sustainability it is likely to be relevant to determine to what extent a given ecosystem asset has the capacity to produce a set of ecosystem services into the future. Determining the answer is as much an ecological question as an economic one.

[2] A useful reference in this context is a paper on the potential to extent the national accounts to non-market areas by Nordhaus (see Nordhaus, W.D. (2006) "Principles of national accounting for nonmarket accounts", in Jorgenson, D. et al. (eds.) *A New Architecture for the US National Accounts*, Chicago University Press, Chicago.) It sets up a framing of near and far markets for non-market services that may be useful in supporting the discussion that is required.

In general terms this is consistent with the concepts applied when incorporating the value of environmental assets in wealth accounting as developed by, for example, Dasgupta (2009), Hamilton and Ruta (2009) and Barbier (2013). However, there is an interesting question about the extent to which valuation approaches used in wealth accounting are consistent with the national accounting exchange values as described in this paper.

It is certainly the case that wealth accounting aims to use marginal prices, referred to as either accounting or shadow prices, as distinct from total values of consumer and producer surplus. However, from a national accounting perspective these "shadow prices" appear to be defined in terms of how much (social) welfare changes when the environmental asset changes (i.e. they are defined as the partial derivative of a social welfare function with respect to changes in the (physical) assets. In which case it is necessary to assume something about a social welfare function which lies somewhat at odds with the aim in the national accounts to be relatively neutral with respect to institutional arrangements and related matters.

Other the other hand, in practice wealth accounting estimates appear to often use observed resource rents for the valuation of environmental assets, e.g. for mineral and timber resources, which would be likely to be consistent with national accounts exchange value principles but, at the same time, would seem to not represent the target shadow prices concept. Further discussion is needed on both the concepts and the practice to better understand the connection and articulate how the SEEA EEA can best support work on wealth accounting and vice versa.

The use of an NPV approach focused on the valuation of ecosystem services may be seen as limiting the potential to assess the value of various characteristics of ecosystem assets including their diversity and resilience. In principle, both of these issues will be tied up in consideration/estimation of the future flows of services, but it would be useful to discuss further the valuation of these characteristics.

3. Issues in developing exchange values for ecosystem services

The sections above provide the background and rationale for an accounting approach to the valuation of ecosystem services and assets. A number of issues were noted in terms of applying accounting principles in the ecosystem measurement context. This section summarises those more general issues and introduces several specific issues that have arisen for some valuation methods and for some services when aiming for an exchange-based valuation.

However, before jumping into a discussion of valuation issues, there are some context factors that will also require on-going discussion. These include:

- Understanding the policy or analytical question and from this point determine whether an exchange value concept is appropriate or whether a welfare-based concept is more relevant. This is critical to avoid the perception that all valuations in monetary terms are comparable.
- Building on this distinction in valuation concepts, further consideration is needed of the potential to compile accounts based on alternative or complementary concepts. Thus, while it will be the case that exchange values will be used to combine ecosystem and economic data into integrated accounts, it may prove appropriate to estimate complementary welfare-based valuations using the same underlying biophysical information as compiled in the physical ecosystem accounts.
- Recognising the relevance of non-monetary valuation approaches and integrating the relevant information into decision making contexts. It is clear that placing a

monetary value on all aspects is not possible (or even desirable) and hence there is the potential within the ecosystem accounting framework to organise the relevant biophysical information to support discussion beyond monetary valuation.

It is also noted at this point that the application of the various valuation techniques taking into account the various conceptual issues will require much clearer and more commonly understood descriptions of the various ecosystem services and the distinctions from the associated benefits. The lack of clarity in whether valuation approaches are targeting services or benefits makes comparison between valuation methods very difficult.

General conceptual issues

Building on the discussion in the previous section, there are a number of conceptual issues that require further investigation and discussion to clarify the position for ecosystem accounting. The key issues are:

- Establishing a description of the economic assumptions underpinning the SNA concept of exchange values in the context of non-monetary transactions, in particular the assumptions regarding institutional arrangements. With this information, an effective discussion can be held with economists implementing valuation methods.
- Determining the treatment of non-use values in the context of exchange values. It is possible to conclude that non-use aspects of ecosystem asset value cannot be transacted in which case no exchange value can exist and the value must therefore reflect only consumer surplus. At the same time, where positive estimates exist for people's willingness to pay for non-use aspects, e.g. through donations to save endangered species, some exchange value would seem to emerge. Reconciling these perspectives is an important issue.
- Developing ecologically and economically meaningful estimates of the future flows of services that take into account both the expected changes in the capacity of the ecosystem to generate services and expected changes in the demand for ecosystem services due to, for example, changes in population and increases in household incomes.
- Understanding the relationship between observed values for land and the net present value of land based on the aggregation of ecosystem services is a critical issue that speaks directly to the way in which accounting information can be used to influence economic behaviour.
- As noted above, consideration is needed of the possible approaches to the valuation of biodiversity and other characteristics of ecosystem assets.
- If values of ecosystem assets based on NPV can be estimated, then the valuation of degradation can be reasonably readily derived. What is less clear is how that value of degradation might be allocated to specific economic units and, separately, how to account for human activity that enhances the condition of an ecosystem asset. Both of these issues are key accounting issues requiring further discussion.

It is also noted that the descriptions above may easily be interpreted as implying that in ecosystem accounting the production of ecosystem services can be simply assigned to an individual ecosystem asset, in much the same way as the production of goods can be assigned to an individual factory. In reality, a number of ecosystem services will be produced by several ecosystem assets (distinguished by being of different ecosystem types) working in

combination. For example, the regulation of water flows in a catchment may be a function of forests, grasslands, agricultural land and urban areas. The SEEA EEA recognises this reality but rather than change the concept of an ecosystem asset to vary depending on the service, the approach is to attribute the total ecosystem service estimated at the "landscape" level among the relevant ecosystem assets according to their relative contribution in the delivery of the service. While this notion of attribution is simple to express, its estimation in practice may be far more complex.

Specific methodological issues

Initial investigations and discussions during the drafting of the SEEA EEA in 2011 and 2012 revealed the range of different valuation methods that have been applied in valuing ecosystem services. The focus of discussion since that time has tended to be on the extent to which a particular method could be used to estimate exchange values for accounting purposes. The current state of the discussion on this is presented in the table below which is from the SEEA EEA Technical Recommendations. Finalising this way of approaching the challenge would be useful and would require resolution of a number of the conceptual points introduced above. The Bonn workshop should be a good forum to update and advance the content of the table.

Of particular interest is understanding:

- How to best treat situations in which the derived resource rent (i.e. the residual after deducting costs from sales of an extracted or harvested outputs) is very low or negative. Again, institutional arrangements are likely to be a key factor to consider in this context.
- The potential of cost based approaches[3] to estimate exchange values, particularly since the views of the merits of these approaches seems to divide the valuation community, Noting above the common use of cost based approaches to value non-monetary transactions in national accounts, it should be recognised that accountants tend to be drawn to the use of cost based approaches, in large part because costs of production and assets are commonly observable or more easily estimated than associated benefits, but the precise assumptions and implications need to be more fully articulated.[4]
- The potential of simulated exchange value approaches where an exchange value is estimated through estimation of both a supply and a demand curve
- The extent to which prices revealed through Payment for Ecosystem Services (PES) schemes and other environmental markets can be used to estimate exchange values. Particular issues here concern include understanding the role of government, clarifying the links to replacement and damage costs and recognising the extent to which prices revealed in markets reflect the full value of ecosystem services. Smith et al (2017) discuss a range of issues and options in this space under the general theme of "posited" (hypothetical) markets.

[3] Following the labels in the table below these include valuation approaches of replacement cost, averting behaviour, damage costs, restoration costs and travel costs.

[4] At the same time, particularly in reference to assets, national accounting does not apply the concept of historic cost accounting and instead aims to value asset at a given point in time in terms of the benefits that could have been secured at that time by using the asset in alternative ways, including through sale. The valuation concept in this case is, in economic terms, the opportunity cost and it is reflected in accounting terms in the use of current cost accounting principles. For further discussion see SNA 2008 paragraphs 1.65-1.67.

SEEA EEA Technical Recommendations: Table 6.1: Summary of valuation techniques and their use in ecosystem accounting

Valuation technique	Description	Comments	Suitability for valuation of individual ecosystem services	Applicable for the following ecosystem services
Unit resource rent / Net factors of production	Prices determined by deducting costs of labour, produced assets and intermediate inputs from market price of outputs (benefits).	Estimates the average value of ecosystem service, not marginal. Estimates will be affected by the property rights and market structures surrounding production. For example, open access fisheries and markets for water supply often generate low or zero rents.	In principle, this method is **appropriate** but care is needed to ensure that the residual estimated through this approach is limited to the target ecosystem service.	Provisioning services involving harvest or abstraction (e.g. concerning timber, fish, crops, livestock, etc.) Potentially, also applicable to cultural services such as recreation provided by established businesses.
Production function, cost function and profit function methods	Prices obtained by determining the contribution of the ecosystem to a market based price using an assumed or estimated production, cost or profit function.	In principle, analogous to resource rent but generally can be better targeted to focus only on specific ecosystem services and models more able to take into account ecological connections. Can reveal marginal value of ecosystem service. However, more data intensive and require benefit transfers methods for higher level aggregates.	**Appropriate** provided the market based price being decomposed refers to a product rather than an asset – e.g. value of housing services rather than the value of a house.	Prices for all type of ecosystem services may be estimated using this technique provided an appropriate production or similar function can be defined. This will require that the ecosystem services are direct inputs to the production of existing marketed goods and services. It is likely to be of most relevance in the estimation of prices for provisioning services and for certain regulating services that are inputs to primary production, e.g. water regulation.
Payment for Ecosystem Services (PES) schemes	Prices are obtained from markets paying for specific regulating services (e.g. in relation to carbon sequestration)	Estimates will be affected by the type of market structures put in place for each PES (see SEEA EEA 5.88-94). Because payments are not typically conditional upon ecosystem service delivery, prices do not represent true consumer or producer surplus.	**Possibly appropriate** depending on the nature of the underlying institutional arrangements.	Given the most common focus of PES schemes, the price information will be most applicable to the valuation of regulating services, e.g. carbon sequestration.
Hedonic pricing	Prices are estimated by decomposing the value of an asset (e.g. a house block including the dwelling and the land) into its characteristics and pricing each characteristic through regression analysis	Very data intensive approach and separating out the effects of different characteristics may be difficult, unless there are large sample sizes.	**Appropriate in principle**, if an individual service can be identified. Heavily used in the pricing of computers in the national accounts.	Most commonly applied in the context of decomposing house and land price information and hence will be relevant for those ecosystem services that impact on those prices. Examples include access to green space, amenity values and air filtration. A challenge is attributing the estimated prices to the location of supply.

Replacement cost	Prices reflect the estimated cost of replacing a specific ecosystem service using produced assets and associated inputs.	This method requires an understanding of the ecosystem function underpinning the supply of the service and an ability to find a comparable "produced" method of supplying the same service. Over-estimates value when no reasonable replacement is available.	**Appropriate** under the assumptions (i) that the estimation of the costs reflects the qualities of the ecosystem services being lost; (ii) that it is a least-cost treatment; and (iii) that it would be expected that society would replace the service if it was removed. (Assumption (iii) may be tested using stated preference methods and should take into account the potential scale issues in replacing the service.)	The idea of replacement cost assumes that a service can be replaced, i.e. that a man-made alternative can be developed. In general, this engineering type focus will mean that the method would be applied for various regulating services such as water regulation, water purification and air filtration.
Damage costs avoided	Prices are estimated in terms of the value of production losses or damages that would occur if the ecosystem services were reduced or lost due to ecosystem changes (e.g. as a result of pollution of waterways).	May be challenging to determine the value of the contribution/impact of an individual ecosystem service.	**Appropriate** under the assumptions (i) that the estimation of the damage costs reflects the specific ecosystem services being lost; (ii) that the services continued to be demanded; and (iii) that the estimated damage costs are lower than potential costs of abatement or replacement.	Similar to replacement costs, the focus will generally be on services provided by ecosystems that are lost due to human activity impacting on environmental condition, particularly through pollution. Regulating services are likely to be the most commonly estimated using this method.
Averting behaviour	Prices are estimated based on individual's willingness to pay for improved or avoided health outcomes.	Requires an understanding of individual preferences and may be difficult to link the activity of the individual to a specific ecosystem service.	**Possibly appropriate** depending on the actual estimation techniques and also noting the method relies on individuals being aware of the impacts arising from environmental changes.	
Restoration cost	Refers to the estimated cost to restore an ecosystem asset to an earlier, benchmark condition. Should be clearly distinguished from the replacement cost method.	The main issue here is that the costs relate to a basket of ecosystem services rather than a specific one. More often used as a means to estimate ecosystem degradation but there are issues in its application in this context also.	**Likely inappropriate** since it does not determine a price for an individual ecosystem service but may serve to inform valuation of a basket of services.	
Travel cost	Estimates reflect the price that consumers are willing to pay in relation to visits to recreational sites.	Key challenge here is determining the actual contribution of the ecosystem to the total estimated willingness to pay. There are also many applications of this method with varying assumptions and techniques being used with a common objective of	**Possibly appropriate** depending on the actual estimation techniques and whether the approach provides an exchange value, i.e. excludes consumer surplus. A distinction here is that the total of actual travel costs is not a measure of the value of the	This will relate to valuation of recreational ecosystem services.

		estimating consumer surplus. Finally, some travel cost methods include a value of time taken by the household which would be considered outside the scope of the production boundary used for accounting purposes.	ecosystem services but it may be appropriate to use the demand profile associated with the travel cost (the estimation of this demand curve is referred to as use of the travel cost method).	
Stated preference	Prices reflect willingness to pay from either contingent valuation studies or choice modelling.	These approaches are generally used to estimate consumer surplus and welfare effects, and non-use (bequest and existence) values. Within the range of techniques used there can be potential biases that should be taken into account.	**Inappropriate** since does not measure exchange values. However, while the direct values from stated preference methods are not exchange values, it is possible to estimate a demand curve from the information and this information may be used in forming exchange values for ecosystem services.	
Marginal values from demand functions	Prices are estimated by utilising an appropriate demand function and setting the price as a point on that function using (i) observed behaviour to reflect supply (e.g. visits to parks) or (ii) modelling a supply function.	This method can use demand functions estimated through travel cost, stated preference, or averting behaviour methods. The use of supply functions has been termed the simulation exchange value approach (Campos & Caparros, 2011)	**Appropriate** since aims to directly measure exchange values. However, the creation of meaningful demand functions and estimating hypothetical markets may be challenging.	In principle, may be applied for many types of ecosystem services but most likely to be relevant in the estimation of values for regulating and cultural services.

Separately from a focus on specific valuation methods, a parallel focus is to consider individual ecosystem services and to provide advice on which methods would be most useful in estimating exchange values. With this approach in mind, the Bonn workshop has structured several sessions which focus on specific ecosystem services so as to generate discussion on the most appropriate valuation methods. Given their relevance in most parts of the world and also their complexity, a detailed focus on the valuation of water-related ecosystem services would be of particular interest. Also, far more discussion is needed in relation to cultural services. Here the target of valuation (i.e. what is the ecosystem service being transacted) is often unclear and the valuation methods used (often travel cost) seem to utilise a range of existing economic data already included in the economic accounts.

In the discussion on applying valuation methods for individual ecosystem services it will be important to distinguish practical concerns from theoretical concerns. A good example here is hedonic pricing approaches. From a national accounting perspective, these approaches appear to satisfy the requirements of estimating an exchange value and indeed hedonic pricing is used quite widely in consumer prices indexes and national accounts around the world. At the same time, it is recognised that there are significant practical and compilation challenges in using this method that may preclude it from use in ecosystem accounting. Across all of the methods we should be clear as to the reason for a method not being applied. A related issue here concerns the use of benefit transfer methods to estimate values where primary information for a given ecosystem service in a given location is not available.

Finally, it is noted that the use of information on the relationship between ecosystem services and human health outcomes is problematic from a national accounting perspective. Health outcomes of individuals are not valued in the measurement of output in the national accounts which focus instead on the level of service provided by doctors, nurses, hospitals, etc. Further consideration is therefore required about the valuation of a range of ecosystem services by, for example, considering the extent to which declines in ecosystem services that result in poor health outcomes and which then may lead to increased health costs should be captured in a set of accounts aligned to the SNA.

Conclusion

The intention of this paper was to provide a basis for a common understanding of the national accounts approach to valuation that underlies the SEEA EEA framework. Commonly, the national accounts valuation is misunderstood and it is hoped that this paper can build understanding to support the valuation of ecosystem assets and ecosystem services and, in doing so, encourage better informed decision making.

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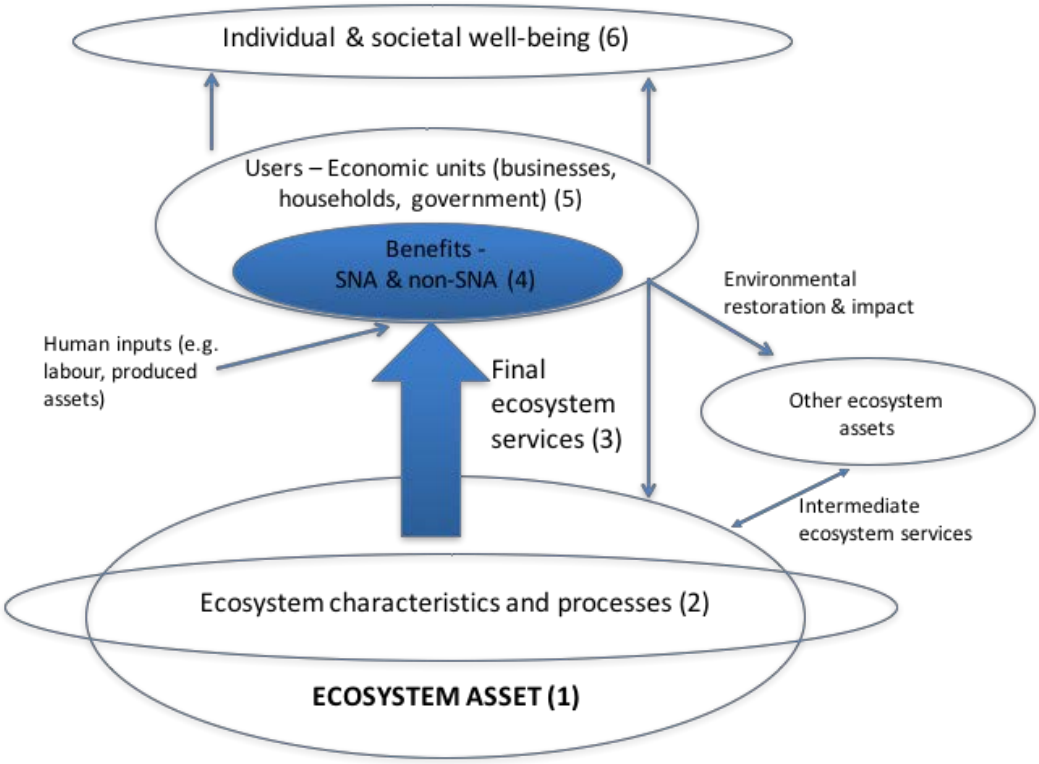
Annex 1: Overview of the SEEA EEA ecosystem accounting framework

SEEA EEA Technical Recommendations – Section 2.2

2.2 The SEEA EEA ecosystem accounting framework

2.1 The SEEA EEA ecosystem accounting framework has five main components that are reflected in Figure 2.1. Starting at the bottom of Figure 2.1, the framework is based around accounting for the various biotic and abiotic components within an **ecosystem asset (1)** that is represented by a spatial area.[5] The delineation of the area that defines an ecosystem asset is required for accounting purposes and should be considered a statistical representation of ecosystems, even though by their nature they are not discrete systems that align to strict spatial boundaries. There will be different types of ecosystem assets within a territory (e.g. forests, wetlands) which will need to be distinguished. Approaches to the delineation of spatial areas for ecosystem accounting are described in Chapter 3.

Figure 2.1: Ecosystem accounting framework



Source: Adapted from SEEA EEA Figure 2.2, UN et al., 2014b.

2.2 Each ecosystem asset has a range of relevant **ecosystem characteristics and processes (2)** that together describe the functioning of the ecosystem. While each ecosystem asset is uniquely defined, ecosystem processes will generally operate both within and across individual ecosystem assets. Thus, while in Figure 2.1 ecosystem assets are shown as discrete areas, the associated ecosystem processes are considered to be unbounded and hence extend beyond the asset boundaries.

[5] Some of these components may be accounted for individually using the asset accounting descriptions in the SEEA Central Framework – e.g. accounts for timber, water and soil.

2.3 The accounting framework proposes that the stock and changes in stock of ecosystem assets is measured by assessing the ecosystem asset's **extent and condition** using indicators of the relevant ecosystem asset's area and characteristics. The extent and condition of an ecosystem asset will be affected by natural changes and also by human activity in the landscape. While each ecosystem asset is considered separable for accounting purposes there will be connections with **other ecosystem assets** reflecting both the movement of water, energy and materials and flows of intermediate ecosystem services (such as pollination services). The measurement of ecosystem extent is described in Chapter 3 and the measurement of ecosystem condition is described in Chapter 4.

2.4 Each ecosystem asset generates a set or basket of **final ecosystem services (3)** which are defined as contributions to the production of benefits. Final ecosystem services encompass a wide range of services provided to economic units (businesses, governments and households) and may be grouped into provisioning services (i.e. those relating to the supply of food, fibre, fuel and water); regulating services (i.e. those relating to actions of filtration, purification, regulation and maintenance of air, water, soil, habitat and climate) and cultural services (i.e. those relating to the activities of individuals in, or associated with, nature).

2.5 **Benefits (4)** may be *SNA benefits* - goods or services (products) produced by economic units (e.g. food, water, clothing, shelter, recreation) currently included in the economic production boundary of the SNA; or *non-SNA benefits* – benefits that accrue to individuals, or society generally, that are not produced by economic units (e.g. clean air). By convention, the measurement scope of non-SNA benefits for ecosystem accounting purposes is limited to the flow of ecosystem services with a direct link to human well-being.

2.6 In the accounting system, for each supply of final ecosystem services there is a corresponding use that leads to the production of either an SNA or non-SNA benefit. Further, in each sequence of use of ecosystem services and production of benefits there is an associated **user (5)** being an economic unit – business, government or household. Thus, every final ecosystem service flow represents an exchange between an ecosystem asset (as a producing/supplying unit in the accounting system) and an economic unit. Both SNA and non-SNA benefits contribute to **individual and societal well-being (6)**.

2.7 The measurement of ecosystem services in physical terms is described in Chapter 5 and the valuation of ecosystem services is described in Chapter 6. Ecosystem accounting does not focus on the measurement of individual or societal well-being. It is noted however, that in some decision-making contexts there may be direct interest in the assessment of well-being and the choice of valuation approach may be varied to take this in account. While the ecosystem accounts do not present valuations of well-being and welfare change, the ecosystem accounting framework provides information, particularly biophysical information, that is relevant to this form of analysis.

2.8 A key motivation for ecosystem accounting is to understand the potential for ecosystem assets to provide services into the future and hence contribute to sustainable overall individual and social well-being. In this context, the scientific literature on ecosystem accounting has proposed four concepts in relation to ecosystem services (Hein et al., 2016, building upon among others Bagstad et al., 2014 and Schröter et al., 2014). These are: (i) the *actual flow* of ecosystem services, as recorded in the ecosystem services supply and use account; (ii) the *capacity* of ecosystems to supply services, corresponding to the sustainable flow of services subject to there being demand for such services (flow equals capacity for regulating services); (iii) the *potential supply* of services, indicating the potential, sustainable flow of services assuming no limitations in demand for the service (hence potential flow is a function of ecosystem characteristics only, it is not influenced by the presence of people using the service); and (iv) *ecosystem capability*, reflecting the ability of the ecosystem to generate services if it where managed in a different way. Potential supply and capability are concepts that are relevant for environmental management, and less so for accounting (although it can be noted that condition accounts are most directly linked to the potential of the ecosystem to supply services

rather than to the actual service supply that also depends upon human use of the ecosystem). These concepts are further discussed in Chapter 7.

2.9 Finally, the aggregate contribution and role of all ecosystem assets will be relevant in understanding national level changes in wealth and associated concepts of sustainability. The integration of information on ecosystem assets and services with data from the SNA accounts is described in Chapter 8.

Annex 2: Atkinson and Obst (World Bank 2017) Prices for Ecosystem Accounting - Executive summary

The intent of the paper

The intent in pursuing this research is to activate a dialogue among economists and national accountants about the approaches to valuation of ecosystems and ecosystem services. For too long, these two groups of experts have managed to consider issues related to the valuation of non-market environmental stocks and flows in relative isolation. The emergence of the System of Environmental-Economic Accounting - Experimental Ecosystem Accounting (SEEA EEA) through 2012 has brought the question of valuation of these stocks and flows firmly back into the view of national accounts experts.

At the same time, the application of valuation approaches developed in the space of environmental economics have been increasingly called upon to support the valuation of ecosystem services at both small and large scales. Given the growing interest in both accounting and economic valuation in an environmental context, this paper describes the extent to which ecosystem service values estimated using valuation techniques in environmental economics are consistent with valuation principles of the System of National Accounts (SNA) and which are also applied in the context of ecosystem accounting.

Past dialogue on this topic has led to the overall conclusion from the perspective of the national accountants that the values generated through most environmental economic techniques are not appropriate for use in accounting. Therefore, to advance the discussion it is necessary to return to the conceptual underpinnings of both economic valuation and national accounting. Indeed, important parts of the paper involve explaining aspects of environmental economics to accountants and explaining the ecosystem accounting approach of the SEEA to economists. These explanations are not intended to be exhaustive and for additional details on these topics readers are encouraged to consider additional literature.

With a focus largely on conceptual issues, the paper does not provide specific guidance for compilers in the implementation of valuation techniques. However, it does make progress in advancing the understanding of national accounting requirements and the potential of environmental economics to be applied in that context. It is intended that this progress can underpin the development of practical guidance for compilers in this area.

Not all conceptual issues are pursued in this paper. The focus has been placed on the valuation of flows of ecosystem services as distinct from valuation of the underlying stocks of ecosystem assets. There are close links between these two targets of valuation, but there are a number of important additional considerations with respect to the valuation of assets that require separate discussion.

Key findings

The following are the key findings of the paper.

The framing of ecosystem services

First, reaching a common understanding of the description of the relationships between ecosystem assets, ecosystem services, the associated economic units (businesses, governments and households), and the benefits enjoyed by these units remains a work in progress. When presented in relatively broad terms, there is agreement about the existence and importance of the links between ecosystem services (both market and non-market) and underlying stocks of ecosystem assets from which they are generated and the use of these services by economic units. It is clear however, through the drafting and discussion process on this paper, that the precise description of these relationships is not agreed. At a practical level, this perhaps does not have a significant impact in the short term. However, without reaching a common articulation of these relationships and the associated measurement boundaries, the dialogue

and exchange on these topics is confusing. It also makes it difficult for newcomers to the discussion to contribute. Ultimately, it will be important to continue to press towards an agreed description. It is hoped that the discussion in this paper represents an important contribution in this regard.

The purpose of valuation and institutional arrangements

Second, understanding the purpose of valuation is important in ensuring the discussion of valuation techniques is being considered with the same valuation target in mind. This was a general finding of the SEEA EEA but the discussion in this paper provides a stronger conceptual context for this conclusion. The general objective of valuation for accounting purposes is to estimate a price for a flow of ecosystem services that has already taken place. Thus, accounting is retrospective in its outlook and must frame the valuation in the context of a past reference accounting period.

It transpires that this view is not completely incongruent with the economic conception of price. Indeed, any incongruence is often an artefact of a different use of valuation in environmental economics: notably, where the aim is to establish or model an ideal or shadow price that would reflect a situation in which ecosystem services flows were optimally provided at socially desired (rather than actual) levels. To this end, this sort of use typically considers an alternative scenario with associated assumptions concerning institutional arrangements etc.

Congruence can exist, however, where valuation in environmental economics is used to identify prices for ecosystem service flows associated with current institutional arrangements. The challenge then lies in deciding which institutional arrangements are appropriate for national accounting purposes. At this time, a clear answer to this question cannot be provided. However, the discussion here:

- makes clear that the valuation of ecosystem services for ecosystem accounting will require acceptance of and assumptions regarding institutional arrangements
- explains that making assumptions concerning these arrangements is not incompatible with national accounting but equally the assumed arrangements are likely to be different from the type of ideal market arrangements that may be most commonly applied in environmental economic valuation
- highlights that the economics literature provides a range of alternative models for both the demand and supply side arrangements that may be used to inform a decision for national accounting purposes.

Resolving the treatment of consumer surplus

Third, an important conclusion is that the long-standing reservation of national accountants concerning consumer surplus should be considered resolved. Recalling the retrospective nature of accounting, it is certainly the case that accounting does not record amounts of consumer surplus since these amounts cannot be traded. So for any given transaction, however effectively a seller can price discriminate among buyers, the implied or revealed transaction price cannot, by definition, include any consumer surplus for that specific transaction. It is also the case that it is common for environmental economics valuation techniques to be used to estimate levels of and changes in consumer surplus in alternative scenarios (as noted above). National accountants have traditionally used these two points to argue that the values and the valuation techniques themselves are, therefore, inappropriate for accounting.

However, the reality that clearly emerges from this paper is that, while environmental economics valuation techniques can be used to estimate consumer surplus, in order to do this they estimate marginal prices and describe demand curves for given goods or services. This is a potential starting point for the estimation of prices for accounting and it is clear that the techniques of environmental economics cannot and should not be dismissed on the grounds that they are used to estimate consumer surplus. National accountants should become far more willing to engage in this important area of work.

The practical reward is that this opens a rich empirical record of data on economic prices that may be considered for use in an accounting context.

Using ecosystem service channels

Fourth, in returning to the underlying framework behind the environmental economics valuation techniques, the paper describes the framing of ecosystem services valuation in terms of ecosystem service channels (Freeman *et al*. 2013). The three channels described in this paper represent the different ways in which economic units (primarily businesses and households) engage with ecosystems. Valuation techniques can be grouped in terms of those that are most suited to valuation of different channels.

This long-standing framing of valuation techniques has been applied in this paper in two ways. From an accounting perspective, the concept of channels between ecosystems and different economic units aligns very well with the concept of the supply and use of ecosystem services as developed in ecosystem accounting. This finding of a common framing in both environmental economics and national accounting is important as it provides a fundamentally strong point of departure for ongoing dialogue, identifying as it does the character of the transaction that is taking place.

In addition, by considering valuation techniques from the perspective of channels, the focus is shifted from applying valuation techniques purely on the basis of the type of ecosystem service. Most commonly, at least in accounting applications, the valuation of ecosystem services has first described a particular service and then sought out an appropriate technique for that service. The channels approach to framing however, suggests a more refined starting point of identifying both the type of service and the user of the service. As a consequence, it is likely that certain techniques may be able to be applied in a wider range of situations than usually considered. The channels framing is not a panacea but in terms of better ascribing valuation techniques to the range of transactions in ecosystem services that are within scope of accounting it is an important step forward.

Applying valuation techniques

Finally, based on these conceptual discussions and framings, the following conclusions can be drawn in terms of application of environmental economics valuation techniques for use in estimating prices for accounting purposes.

- Production, cost and profit function techniques can be considered for use in valuing all types of ecosystem services (provisioning, regulating, cultural) that provide an input to businesses. Conceptually, the ideas behind these methods are well aligned with national accounting valuation principles.
- Hedonic techniques may be applied for specific ecosystem services. The theory behind these methods is well aligned with national accounting valuation principles.
- There is a range of techniques including defensive expenditures and travel costs, that use information on expenditure, especially by households, as a means to estimate demand for specific ecosystem services. If combined with a suitable estimate of the level of supply, this information can form the basis for valuing various ecosystem services, particularly regulating and cultural services.
- The estimation of stated preferences using contingent valuation or choice experiment techniques can support the derivation of a demand curve for those ecosystem services with clear public good characteristics. Again, determining a corresponding estimate of supply is required for the derivation of prices for accounting purposes.
- The use of cost based techniques such as replacement cost and restoration cost are not strongly supported within the environmental economic community. The primary concern is that the estimation of these costs does not take into consideration the preferences of the users or

beneficiaries (or at least does not provide evidence to reassure about these preferences). The environmental economic literature identifies three requirements before a cost-based valuation should be accepted – whether the costs relate directly to the service being measured, whether the costs reflect the least cost alternative, and whether the costs would actually be paid if the ecosystem service were lost. In the evaluation of this last criteria the need to find cost-effective but meaningful ways of seeking assurance that these approaches do capture the views of beneficiaries, may point to a role for environmental economic techniques.

- The use of information on the relationship between ecosystem services and human health outcomes is problematic from a national accounting perspective. Health outcomes are not valued in the measurement of output in the national accounts which focus instead on the level of service provided by doctors, nurses, hospitals, etc. Further consideration is therefore required about the extent to which declines in ecosystem services that result in poor health outcomes and which then may lead to increased health costs should be captured in a set of accounts aligned to the SNA.

Conclusions and next steps

The research and associated discussion presented in the paper has made some positive steps towards a more common understanding of the valuation requirements for accounting and the potential of existing valuation techniques to be applied. It is clear that this discussion must continue while at the same time, practical application of valuation techniques for accounting purposes must also tested and the feedback used to inform ongoing conceptual discussions.

Using the framing provided in this paper it is planned to pursue two additional directions. First, the description of more specific advice on the use of the methods associated with different channels to the estimation of transaction prices for specific ecosystem services. This work will be directed towards supporting current efforts in ecosystem accounting. Second, the extension of the introductory discussion of the valuation of ecosystem assets provided in this paper. Issues such as the estimation of asset lives, the choice of discount rates and integration with existing national accounts balance sheet values are of particular relevance. The aim in both of these extensions is to utilize the existing expertise and experience across the economic and accounting disciplines to find solutions to clear and current measurement challenges.