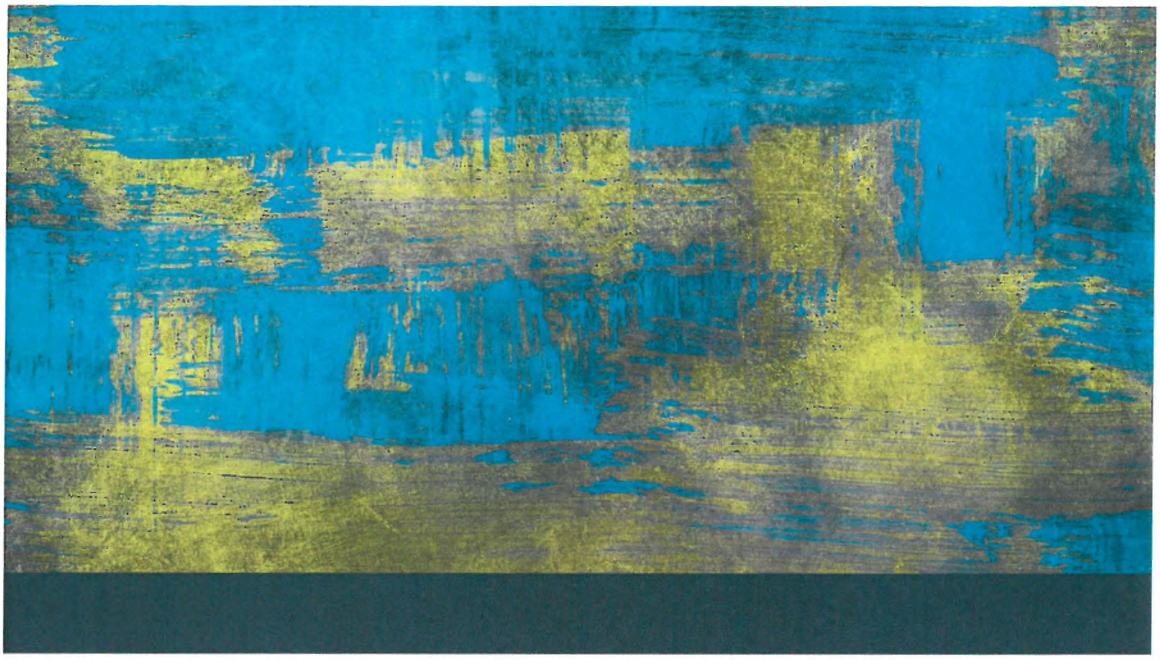

INCLUSIVE WEALTH REPORT 2018

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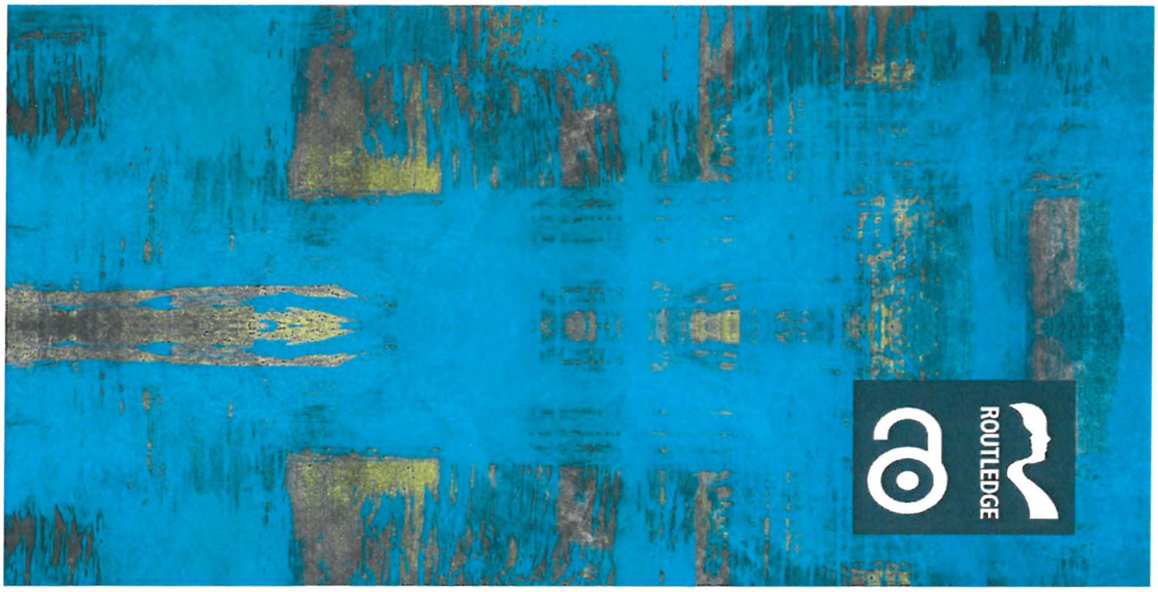

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5 Challenges to ecosystem service valuation for wealth accounting

Kristine Grimsrud, Henrik Lindhjem, David N. Barton, and Ståle Navrud

1. Introduction

The inclusive wealth framework is a tool to analyse "society's sustainability" (Dasgupta and Duraiappah 2012), which may be interpreted as non-declining human well-being over time. Dasgupta and Duraiappah (2012, p. 22) argues that the best index to track human well-being over time is society's wealth, where "wealth is the social worth of an economy's capital assets". Further, the inclusive wealth framework defines the aggregate wealth as the shadow value (or price) of the stocks of all assets of an economy, and suggests that ecosystems should be included as an important form of "natural capital" in this wealth. Shadow values are a key measure to inclusive wealth. Dasgupta and Duraiappah (2012) define the shadow price/value of a capital asset as the monetary measure of the contribution a marginal unit of that asset is forecast to make to human well-being. The shadow value is thus a more comprehensive measure of value than, for example, (unadjusted) market prices. Shadow prices internalize environmental (and other) externalities and capture the substitutability of the capital assets not just in the present period but also in the future. The inclusive wealth framework can accommodate non-linear processes of natural systems and provide early warnings in the process to avert such thresholds from being reached if the shadow prices are estimated using certain valuation methods (e.g. the so-called production function approach).

The major challenge, however, is to estimate the shadow prices of the natural and ecosystem capital assets. For example, we do not have full knowledge of the production functions of life supporting systems. Dasgupta and Duraiappah (2012) recognize that we may never get the shadow prices "right," instead we can simply try to estimate the range in which they lie. The next best solution, they argue, is to use shadow prices based on willingness to pay measures, while recognizing that these shadow prices may not capture threshold effects of an ecosystem (Farley 2012).

The inclusive wealth accounting framework proposes to expand the net domestic product (NDP), which equals the gross domestic product (GDP) adjusted for appreciation/depreciation of capital, as is currently measured in most national economies, in two ways:

1 The NDP should include the depreciation or appreciation of human and natural capital (i.e. natural resources and ecosystems) as well.
2 The basis for valuing the capital stocks should be shadow prices. Exchange values as is currently used in statistical offices may be used if the exchange values are a good approximation to the shadow prices.

In the System of National Accounts (SNA) goods are valued using exchange values when such values are available. The reason is that national accounts aim to provide a measure of production, not welfare as such, and therefore exclude consumer surplus. While the exchange value often is the market price, it is important to be aware of some slight nuances between the concept of a market price and an exchange value. Market prices depend on level of scarcity and on market conditions. The following definition has been used for market price: "Market prices are the amounts of money that willing purchasers pay to acquire goods, services or assets from willing sellers" (EC et al. 2009, para 3. 119). In national accounting one refers to "exchange values" and not to "market prices" where an exchange value is "the value at which goods, services and assets are exchanged regardless of the prevailing market conditions" (Obst et al. 2016).

The inclusive wealth accounting framework and the System of Environmental Economic Accounting (SEEA) (United Nations et al. 2014a) of the UN have several challenges in common in terms of valuing natural resources and ecosystems. Both accounting frameworks have as a goal to account for the importance of ecosystem and natural capital stocks to society. SEEA aims to better account for the relationships between the economy and the environment and the stock of environmental assets and how environmental assets benefit humanity. The inclusive wealth framework considers the impact of changes in capital stocks on human welfare. A major difference between the two accounting frameworks, is that inclusive wealth requires shadow prices for valuing capital stocks while SEEA requires exchange values in valuing capital stocks. Exchange values are required by the latter to be consistent with the accounting framework of the System of National Accounts (SNA), which countries use to estimate the asset value of produced capital stocks.

Here we focus on the SEEA system for ecosystem accounting, SEEA Experimental Ecosystem Accounting (SEEA EEA) (United Nations et al. 2014b). SEEA EEA has a goal to account for the contribution of ecosystems to production and consumption of economic units including households – where the concept of production and consumption is broader than the standard SNA to include all types of contributions from ecosystems to economic units (Obst 2017, pers. comm.). Both the inclusive wealth framework and the SEEA EEA framework rely on non-market valuation methods for ecosystem assets. SEEA EEA requires that the non-market valuation methods are consistent with the methods used in the field of accounting. The inclusive wealth framework has in past reports drawn more generally on the non-market valuation methods used in environmental economics, and so far, a large number of studies using these methods have been performed. Thus, there is a need to clarify and bridge the gap between the disciplines of accounting and environmental economics when it comes to non-market valuation.

At the same time, there are challenges with the non-market valuation methods that are accepted within both the accounting and the environmental economics communities. Since many of the challenges with using the valuation methods are the same for both accounting frameworks, we will discuss some of the progress that has been made on meeting these challenges in the last version of the SEEA EEA (United Nations 2014b) and the associated draft Technical Recommendations (United Nations 2017).[1] As development and practical implementation and testing of SEEA EEA are moving forward, many of the measurement challenges with valuation of ecosystem services will become better understood and potential solutions are already being discussed. This progress of SEEA EEA is of great relevance for addressing many of the measurement challenges within the inclusive wealth framework (Perrings 2012). A criticism from the accounting community of the various forms of "green accounting" and different indicators proposed to measure macroeconomic welfare in the economic literature, where inclusive wealth is one of several such indicators, has been that they are situated at a very "high level of abstraction without searching any longer for any relationship to actual national accounting measurements" (Vanoli 2005; Obst et al. 2016).

In this chapter we provide an overview of recent progress on the SEEA. In Section 3 we discuss the inclusions of spatially explicit physical and monetary accounts for ecosystems (SEEA EEA). In Section 4 we discuss some key challenges and ways forward for monetary valuation of ecosystem services, benefits and assets within this accounting framework. We use examples from Norway as illustrations. We end the chapter by discussing some limitations of the SEEA accounting framework and future directions.

2. System of Environmental Economic Accounting (SEEA)

The main goal of the SEEA is to better monitor the interactions between the economy and the state of the environment to inform decision-making, typically at the national level. The SEEA framework is consistent with the System of National Accounts (SNA) to facilitate the integration of environmental and economic statistics and the adoption of the SEEA system by national statistical offices. Compared to SNA, the SEEA framework expands the production boundary with the aim to include the whole biophysical environment and a broader set of ecosystem services. SEEA 2012 (United Nations et al. 2014a) builds upon revisions of SEEA 2003 (discussed in the Inclusive Wealth Report 2012 by Perrings (2012)) and SEEA 1993. SEEA contains the internationally agreed upon concepts for producing internationally comparable statistics on the environment and its relationship with the economy. By 2014, 18% of UN member countries had initiated a programme to enhance Environmental Economic Accounting, and 27% of developing countries and 8% of developed countries had a programme for Environmental Economic Accounting. Thus, the current initiatives of the United Nations Statistical Commission (UNSC) to revise and improve the SEEA system appear to be welcomed by member countries. SEEA consists of three parts:

- The SEEA Central Framework (SEEA CF).
- The SEEA Experimental Ecosystem Accounting (SEEA EEA).
- The SEEA Subsystems for Energy, Water, Fisheries and Agriculture. The "subsystems" are consistent with SEEA, but provide further details on specific topics.

The central framework of SEEA, SEEA CF, accounts for individual resources such as timber resources, land, energy and minerals resources, physical environmental flows (such as water, energy, emissions and waste) and environmentally related transactions within the economy (such as environmental protection expenditure and environmental taxes). The SEEA CF was adopted by UNSC in 2012 as the first international standard for environmental economic accounting. The official version of SEEA CF was published in 2014.

Since the publication of the previous Inclusive Wealth Reports, rapid progress has been made in the effort to develop an accounting system for ecosystem flows and assets both in physical and monetary terms through the work on the SEEA Experimental Ecosystem Accounting (SEEA EEA). In 2013, the UNSC endorsed SEEA EEA for further development and testing, and the accounting framework was published in 2014. The SEEA EEA: Technical Recommendations (SEEA EEA TR) presents information that supports the testing and research on SEEA EEA and is motivated by the practical experiences with the accounting framework and advances in thinking on specific topics since the first SEEA EEA (United Nations 2017). The SEEA EEA TR is under revision, and work has been initiated to revise the SEEA EEA by 2020.

Monetary valuation of ecosystem services in SEEA EEA is motivated by several perspectives: input for wealth accounting, demonstration of the contribution of ecosystems to human welfare, and evaluation of policy alternatives. SEEA EEA provides insight into how ecosystems can be considered a form of capital that can appreciate and depreciate, in the same way as other forms of capital such as human, social and economic capital.

The development of the necessary accounting compatible concepts for a spatially explicit accounting system for ecosystem assets and their services is a challenging task, and currently work is in progress. The concepts and thinking developed and implemented in SEEA EEA to date should be helpful in contributing to improve inclusive wealth accounting of natural capital.

3. SEEA Experimental Ecosystem Accounting

SEEA EEA contains spatially explicit physical and monetary accounts for ecosystems. As such, compiling the accounts requires a multidisciplinary approach. To determine rates of asset appreciation or depreciation one also needs these accounts to be compiled regularly over time. SEEA EEA is termed experimental because many concepts for such spatially explicit and repeated accounts for ecosystem services and assets are still under testing and development (see e.g. Remme et al. 2015).

As noted above, the work on developing the SEEA EEA accounts is progressing fast. In the experimental phase the focus is generally on policy relevant case studies where concepts are being developed and tested. In this phase, numbers may not be as accurate as one would desire, but several argue that having approximate numbers that map ecosystems and that can demonstrate their importance to the general economy may be better than the current practice of implicitly valuing ecosystems through our decisions concerning maintaining or transforming ecosystems. Bateman et al. (2013, 2011) show, for example, in the context of the UK National Ecosystem Assessment (UK NEA), that taking account of multiple environmental objectives in systematic environmental and economic analysis of the benefits and costs of land use options, fundamentally alters decisions regarding optimal land use.

Figure 5.1 provides an overview of the conceptual thinking for the ecosystem accounting in SEEA EEA. At the basis for the accounting system are ecosystems. In the accounting terminology, individual contiguous ecosystems are considered ecosystem assets (element 1 in Figure 5.1).[2] Ecosystems are characterized by their

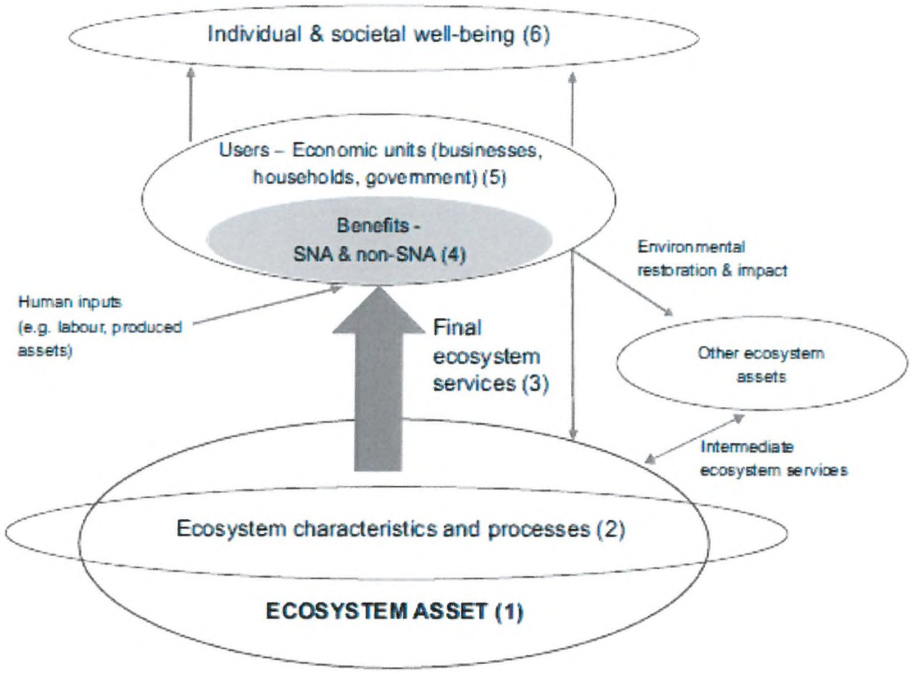

Figure 5.1 Ecosystem accounting framework for SEEA EEA
Source: United Nations (2017).

extent, biotic and abiotic components and their processes. Ecosystem assets may be aggregated into the ecosystem types, for example forests or agricultural ecosystems within the accounting area under study. Ecosystem types are ecosystems with similar ecology and use and are typically not contiguous.

The relevant characteristics and processes describe the ecosystem functioning (element 2). An ecosystem asset delivers ecosystem services, and the focus in SEEA EEA is on final ecosystem services (United Nations et al. 2014b) consistently with Banzhaf and Boyd (2012) and UK NEA (2011) (element 3 in Figure 5.1). Final ecosystem services are either, benefits to users (economic units) directly in themselves or the ecosystem service can be thought of as being an input to production of benefits along with other inputs such as labour and produced assets (e.g. built capital). Both for accounting purposes and for monetary valuation it is important to clarify this distinction between ecosystem services and ecosystem benefits (United Nations et al. 2014b; Banzhaf and Boyd 2012). Making this distinction helps to avoid double counting. The SEEA EEA uses the classification of final ecosystem services 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).

The benefits that are produced by ecosystem services may either be so-called SNA benefits meaning they are already accounted for in SNA (e.g. timber products) or they may be non-SNA benefits, which means they are benefits that are outside the accounting boundary of SNA (e.g. flood protection) (see element 4 in Figure 5.1). It is important to be clear about whether an ecosystem service has already been accounted for in SNA to prevent potential double counting. It is important to make the role of ecosystem services explicit also for those ecosystem services that presently are within the accounting boundary of SNA.

The supply of final ecosystem services is matched with the economic units that receive the benefits (element 5 in Figure 5.1). The economic units are businesses, households and the government. To be consistent with the accounting framework, supply of ecosystem benefits must equal use. The benefits contribute to "individual and societal well-being," the measure of which – according Figure 5.1 – is the ultimate purpose of the accounting framework. As we will discuss, this stated purpose may be misleading because the valuation methods that are consistent with accounting only aim to quantify ecosystems contribution to the economy, not societal well-being or welfare. The accounting system is designed to account for benefits both in terms of physical production and in monetary units where possible.

It should be noted that intermediate ecosystem services are also identified in the framework. Intermediate ecosystem services are those ecosystem services that are inputs to the supply of other ecosystem services. In ecosystem accounting, if one ecosystem produces services that contribute to produce ecosystem services in another ecosystem (e.g. pollination and flood control) these are also considered intermediate (SEEA EEA TR, paragraph 5.40).

Further, the SEEA EEA has five core accounts:

1 Ecosystem extent account – physical terms
2 Ecosystem condition account – physical terms
3 Ecosystem services supply and use account – physical terms
4 Ecosystem services supply and use account – monetary terms
5 Ecosystem monetary asset account – monetary terms

Figure 5.2 describes the relationship between these accounts as a series of physical (a) and monetary (b) steps, arriving at a set of integrated accounts. Even if one may describe this as a sequence of accounts, it should be emphasized that the development of these accounts most often will be iterative permitting one to go back to adjust and make improvements. Hence, an arrow could be drawn from the final step back to the first. Each of the accounts is intended to provide useful information in itself while also being an input into other accounts. Considering the complexity in completing the accounting chain, the identification of 'stand-alone' policy uses of individual accounts is important to motivate further allocation of resources by policymakers to building the system of accounts. In Figure 5.2, ecosystem services supply and use accounts are included as two separate boxes to reflect the iterative process in generating ecosystem services supply and use accounts in physical terms.

SEEA EEA TR includes example tables for all the accounts. These tables are useful illustrations of the accounts but too extensive to include here. The ecosystem extent account maps the area of land in each land use/ecosystem type. Examples of ecosystems here are forests, agriculture, wetlands and urban, although subcategories of these ecosystem types may be deemed necessary depending on the circumstances. For example, natural forest and planted forests for timber production will have quite different characteristics. For each of the ecosystem types, the condition account includes the available and appropriate indicators of the "overall quality of an ecosystem

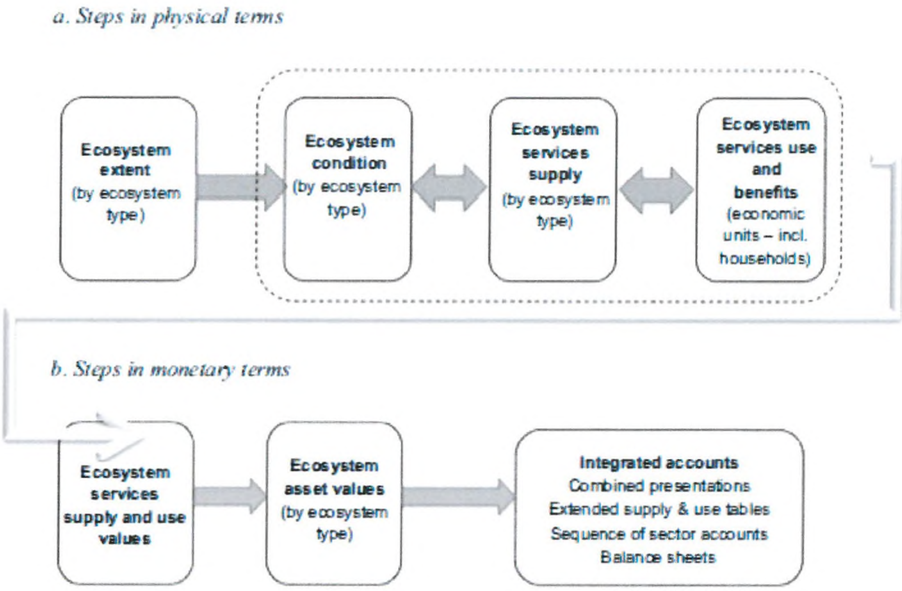

Figure 5.2 Broad steps in ecosystem accounting

Source: United Nations (2017).

asset in terms of its characteristics" (United Nations et al. 2014b, paragraph 2.35). The condition of the ecosystem is the basis for the capacity of the ecosystem to provide ecosystem services in the future, which in turn affects the ecosystem asset value. The ecosystem condition may be evaluated by comparing ecological indicator values now with the ecological indicator values in the reference condition for the ecosystem. What the reference condition should be is discussed in the Technical Recommendations (United Nations 2017) and is part of an ongoing debate, since some ecosystems in some countries have been affected by human beings for such a long time that the ecosystems have evolved to be dependent on human management. One suggestion is to identify the condition that existed when data collection began (United Nations 2017).[3] Depending on the condition of an ecosystem, the ecosystem supplies a basket of ecosystem services, and the ecosystem services use and benefits are further attributed to economic units. Examples of economic units here are households, agriculture, the government and other economic sectors. Again, the subcategories one chooses for the economic units depends on the circumstances, in particular the policy analysis question which accounting should inform. The measurements necessary for the ecosystem condition account, the ecosystem services supply and ecosystem services use may be completed concurrently. This is indicated by the dotted line. Experience with urban ecosystem accounting at high spatial resolution in Oslo has shown that ecosystem extent and condition accounts also need to be determined concurrently, because, depending on the spatial resolution at which land cover is classified, it can also indicate ecosystem condition.

While the first row in Figure 5.2 contains all physical accounts, the second row in Figure 5.2 contains monetary accounts, that we are primarily concerned with here. The first box in the second row is the account for the ecosystem services use and supply values.

In the SEEA EEA TR the ecosystem monetary asset account is defined as accounts that "record the monetary value of opening and closing stocks of all ecosystem assets within an ecosystem accounting area and addition and reductions in those stocks" (United Nations 2017, paragraph 7.5). The motivation for monetary valuation of ecosystem assets in SEEA EEA is twofold. One motivation is that monetary valuation gives a common measurement unit which is – in principle – helpful when comparing alternative uses of ecosystem assets (in practice monetary valuation relies on the completeness of the physical accounts). A second motivation is that monetary valuation permits the ecosystem asset account to be integrated with other accounts for the other capital assets discussed in Chapter 1 of this report. In that sense, compiling the SEEA EEA ecosystem asset accounts and integrating them with the net domestic product could contribute to giving a more complete assessment of a nation's net wealth. As in the inclusive wealth framework, the SEEA EEA framework considers a depreciation of aggregate ecosystem assets a potential sign of unsustainable ecosystem use, but there are some important differences in the view on the meaning and treatment of depreciation in the two frameworks (Obst 2017, pers. comm.).

The thinking regarding the construction of ecosystem asset accounts in SEEA EEA is related but slightly different than the ecosystem capital thinking in the inclusive wealth framework. SEEA EEA is an expansion of the accounting framework in the System of National Accounts. The SNA defines the gross domestic product as a measure of economic performance and states explicitly that GDP is not a measure of human welfare (United Nations et al. 2008). SEEA EEA TR recognizes that there are several perspectives that may be taken when it comes to estimating a nation's wealth in terms of natural and ecosystem capital (United Nations 2017, paragraph 7.1). In the perspective of the inclusive wealth framework, the goal is to maximize intergenerational human welfare derived from all capital stocks. When operationalizing this, the inclusive wealth framework proposes to expand the net domestic product (the depreciation adjusted GDP) to include all types of capital.

SEEA EEA holds that one may account for ecosystem asset, as for any other asset, using a capital theoretic framework. If there is no market for an asset, which is often the case for ecosystem assets, then the monetary value of the asset may be estimated in terms of the present value of the future flow of income attributable to an asset. For an ecosystem asset, estimation of the monetary asset value requires information on:

- The appropriate exchange values now and in the future;
- The expected future ecosystem service supply;
- The appropriate discount rate to calculate the net present value (NPV); and
- The expected life of the asset.

The expected ecosystem service supply should be as close as possible to what one actually expects to be used and the exchange values should be as close as possible to the exchange values one expects for the future.

The final box in Figure 5.2 refers to the integration of ecosystem accounts with the standard national accounts, one of the steps in EEA. Technical guidelines may give the impression that integration of monetary asset accounts with other capital assets is the final purpose of accounting. Further work is needed showing how integrated accounts are a means to the ends of different policy analysis. This may be done in several ways depending on how closely one wants to integrate the accounts. The methods range from combined presentation of only physical data on ecosystem condition and services alongside with presentations of standard national accounts numbers to complete integration where the value of ecosystem assets is incorporated with the values of other capital assets in order to extend the measure of national wealth.

The SEEA EEA offers useful concepts and accounting structures ultimately leading to ecosystem asset accounts. Furthermore, the SEEA EEA provides a framework that is compatible with national accounts and therefore with statistical offices' definitions used in the net domestic product. However, SEEA EEA differs from the theoretical framework of the inclusive wealth model since the latter requires that all the economy's capital assets should be valued at their shadow value.

4. Valuation challenges for ecosystem services, benefits and assets

As noted above, the meaning of an exchange value is quite different from the meaning of a shadow value in terms of its implications for human welfare. Yet, there are some commonalities in terms of the challenges that one may run into when attempting to determine these values. We now discuss some of these challenges.

4.1. Ecosystem service delineation and some fundamental challenges

The definition of an ecosystem service has been widely discussed in the literature in recent years, and the definition in MEA (2005), for example, has been deemed inappropriate for valuation and accounting purposes both in the inclusive wealth framework and in SEEA EEA (Pearson et al. 2012; United Nations 2017, paragraph 5.35). Instead, the need to focus on final ecosystem services and to separate between ecosystem services and ecosystem benefits to avoid double counting has been recognized in both the previous Inclusive Wealth Reports and in the SEEA EEA (see also discussion in Section 3 above). By making the distinction between benefits (also called goods in the UK NEA) and services it is possible to include several ecosystem services that are inputs in the production function of an ecosystem benefit. For example, while harvested fish is an ecosystem benefit, one must subtract the cost of harvesting to find the contribution of the ecosystem (that is the ecosystem service) to the benefit. Several definitions of ecosystem services and goods exist; for example, Barbier (2012) adopts the definition that "ecosystem services are the direct or indirect contributions that ecosystems make to the well-being of human populations (EPA 2009, p. 12)." Whichever definition one adopts, the literature has reached the conclusion that the definition be such that one avoids double counting, and this is possible by focusing on final ecosystem benefits (indirect) and services (direct).

Before we take a practical and pragmatic approach to estimating monetary values for ecosystem services, benefits and assets, it is necessary to recall that many ecosystems are complex and poorly understood both by scientists, policy-makers and the general population (see e.g. the example of the recently discovered cold water corals in Norway discussed in Aanesen et al. 2015). Barbier (2012, p. 163), for example, states: "There is inadequate knowledge to link changes in ecosystem structure and function to the production of valuable goods and services." Since knowledge of ecosystem processes is never going to be complete or perfect, it is likely better to attempt with available knowledge to demonstrate the potential importance and value of ecosystems for human well-being under different methodological assumptions. Implicit valuation by a limited number of decision makers making policy choices uninformed by information on ecosystem services, is unlikely to reach efficient or welfare optimal choices (as noted above in the context of the UK NEA). This is also the argument made by the international project and process of The Economics and Ecosystems and Biodiversity (TEEB) (Kumar 2010).

In the following, we discuss some important challenges with valuation of ecosystem services and benefits that are market (section 4.2) and non-market (section 4.3), respectively, and the valuation of ecosystem assets (section 4.4). We relate the discussion to the framework of experimental ecosystem accounting (cf. back to Figures 5.1 and 5.2 above) and especially the use of methods for non-market services.

4.2. Market ecosystem services and benefits

Many ecosystem services and benefits such as fish, grains, timber and products derived from these have market prices which are relevant exchange values and therefore compatible with national accounting and SEEA EEA. When estimating the contribution of the ecosystem to harvested fish, one estimates the monetary surplus remaining after all costs related to harvesting have been subtracted from the total revenue. This monetary surplus is also denoted as the resource rent. In an accounting framework, it is important to be aware of the impact the institutional arrangement has on the value of the resource rent of many of the provisioning goods. The institutional arrangement may affect both the prices received by fishers and the costs of harvesting, and it is the prices and costs along with the quantity produced that in turn determine the size of the resource rent. For fisheries, examples of institutional arrangements may be open access, quotas or individually tradable quotas, and more. In an open access management regime, the value of the resource rents tends to zero and it is an open question how to value the resource under such circumstances (Hein et al. 2015). But other management regimes can contribute to conceal the resource rent in national accounts even if access to the fishery is limited. Policies that make fishing artificially expensive, for example, may cause the resource rent to be masked in national accounts. For an example of this see Box 5.1. In such cases, there are likely to be other indicators than resources rents

Box 5.1 Institutional arrangements affect the estimated contribution of the ecosystem service for fish

Traditionally, export of fish was a major source of income for Norway. Later other natural resource based income, particularly from oil and gas, overtook fish income. Opposition to new oil extraction in areas that are in important breeding grounds for Norwegian fish stocks confirms the fact that many Norwegians consider fisheries an important natural capital asset to preserve for the future.

Entry to Norwegian fishery is currently managed through fishing licenses and quotas and the fish stocks are not considered overharvested. Yet, for many years, the income from fisheries as it appears in national accounts is negative. Thus, according to national accounts numbers, Norwegian fisheries contributed negatively to Norwegian national wealth in the period 1984–2014 with the exception of 2010–2011 (Greaker et al. 2017). Figure 5.3 shows the components of the resource rent for the period 1984–2014.

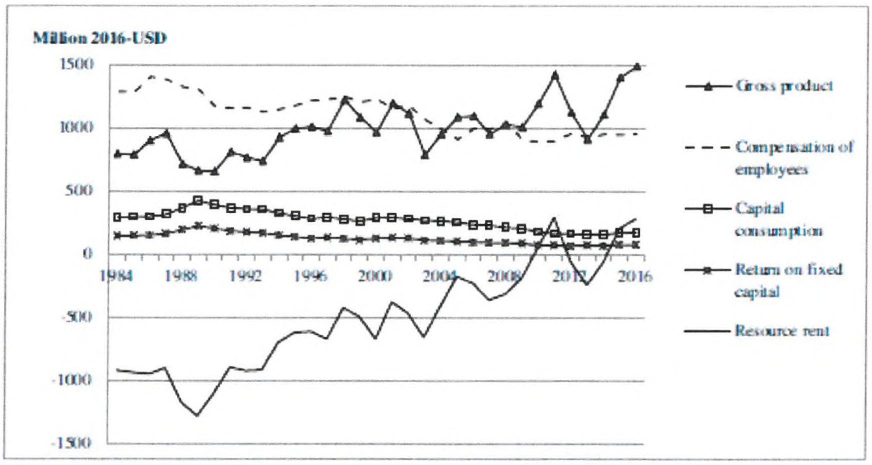

Figure 5.3 Resource rent in the Norwegian fishery 1984–2016

that are of policy importance and which can be monitored, such as employment. In cases where exchange value principles do not provide any additional information, parallel accounts and complementary indicators must be relied upon.

As Figure 5.3 shows, the actual resource rent has generally been on an increasing trend from 1984 to 2016. Norwegian fisheries have in some of the later years had positive resource rent, apart from the period 2012–2014. Factors contributing to the increasing resource rent over time are a year by year reduction in the number of hours worked in the sector reducing total compensation of employees (including compensation to the vessel owner – there are differing views on whether compensation to the vessel owner should be included here). There has also been a year by year reduction in the number of vessels, thus reducing fixed costs and capital consumption, although the gross tonnage has remained fairly constant.

Greaker et al. (2017) hypothesize that the potential value of the fishery resources is higher than what the calculations show in Figure 5.3. The reason is that the values of all parameters entering the calculation of the resource rent are conditional on the existing management regime. This management regime has by law several goals, and one of them is that fisheries should contribute to maintaining viable coastal communities. To help reach this rural development goal, fishing quotas are distributed among fishing vessel with different technologies and geographical locations.

Greaker et al. (2017) explore what the potential resource rent could be in 2011, which was an average year in terms of catch (in the period 2006–2016), without the current distribution of fishing quotas. Using a numerical optimization model, they find that the counter factual resource rent if the 2011 quotas were harvested efficiently with the available technology would be close to 1.6 billion USD. This is 1.20 billion USD more than the observed resource rent.

When decomposing the change in potential resource rent compared to the actual rent into changes in total revenue and total costs, the results show that total revenue falls by about 10%. Simultaneously, total cost falls by around 80%. In 2010 and 2012 the average fish prices were lower. However, if adjusting total revenue and total cost for the national accounts numbers in 2010 and 2012 correspondingly, the potential resource rent is 1.14 and 1.23 billion higher than the one observed in 2010 and 2012, respectively. Even if this is a very simple adjustment, these numbers are not far from the rent dissipation of 1.20 billion USD in 2011. The potential resource rent found here is around 60% of the first-hand value in the fisheries in 2011. This is similar to Wilen's rule of thumb that says that half of the total revenue is resource rent (Wilen 2000).

Some have argued that the ongoing rent dissipation in Norwegian fisheries simply is a way to redistribute income in the fishery sector. But the resource rent could be increased by applying fewer fishers and fewer vessels, and per definition, one is in a situation with resource waste in the fishery sector because well as lower value creation in other sectors because both the fishers and vessels have an alternative value in other industries. However, in cases where the fishers and vessels that are removed from the fisheries have low/zero alternative value in other sectors, the present management system could be described as a more efficient way of financing employment in the fisheries through rent dissipation without leading to lower value creation in other industries as well.

4.3. Non-market ecosystem services and benefits

The most significant challenge for valuation of ecosystem services is that so many of them are non-marketed (Barbier 2014). The field of environmental economics has developed a number of methods to value non-market ecosystem services. Barbier (2012) provides an overview of the progress that has been made in environmental

Box 5.2 Categories of non-market valuation methods

Stated preference methods: Willingness to pay/or to accept compensation for changes in provision of ecosystem services/benefits are elicited from respondents in surveys using structured questionnaires. Stated preference methods are the only methods that can cover non-use/existence values. Well-known methods include contingent valuation and choice experiments.

Revealed preference methods: Values are "revealed" through studying consumers' choices and the resulting price changes in actual markets that can then be associated with changes in provision of ecosystem services. A well-known method is *hedonic pricing* of property characteristics, i.e. where the impact of environmental quality attributes on prices of properties is distinguished from other factors that affect prices. *Travel cost methods* used to value recreational benefits of ecosystems are often also included in this category.

Production/damage function approaches: A group of methods used to value an ecosystem service, where intermediate ecosystem services are one of several "inputs" to the final service or good enjoyed by people. Ecosystems' marginal contribution to the final service is valued.
Cost-based methods: Assume that expenditures involved in preventing, avoiding ("averting"), mitigating or replacing losses of ecosystem services represent a minimum value estimate of what people are willing to pay for the ecosystem service. In ecosystem accounting a distinction is made between replacement cost (of a particular ecosystem service) and restoration cost (of an ecosystem asset and its bundle of ecosystem services).
Benefits/value transfer methods: Refer to the use of secondary, existing study valuation estimates, from any of the valuation methods mentioned above, transferred to the "policy context" in need of value information. Values can either be transferred using unit value transfer methods or more advanced function-based transfers (e.g. based on meta-analysis of the literature).

Sources: Champ et al. (2017); Barton and Harrison (2017); Johnston et al. (2015); Barbier (2012); and Koetse et al. (2015).

economics on developing methodologies for valuation of non-market ecosystem services, and presents the non-market valuation methods that are currently available along with the ecosystem services for which each of the methods is appropriate. These valuation methods are summarized in Box 5.2.

Even if the coverage of environmental valuation studies may be considered patchy across ecosystem benefits and services (Barbier 2014), a large number of valuation studies for ecosystem benefits and services have been carried out in the last few years using environmental economic methods (e.g. Kumar 2010). The ideal would be to have valuation studies specifically designed for accounting purposes. This is rarely the case. This means that accountants and economists typically must use value or benefit transfer methods (see Box 5.2) based on suitable, existing studies to estimate exchange values with typically relatively large uncertainty (see e.g. Johnston and Wainger 2015).[4]

National accountants also have their set of accounting compatible valuation methods for non-market environmental goods (Vincent 2015). Only a subset of the non-market valuation methods developed in environmental economics are considered directly appropriate in an accounting framework ("accounting compatible"). This is because environmental economics is focused on finding estimates of welfare, and as a consequence, most non-market valuation methods that have been developed produce value estimates that include consumer surplus. SNA-compatible accounting requires exchange values, excluding consumer surplus. At the same time, finding accounting compatible monetary values for all ecosystem services is a significant challenge for SEEA EEA (United Nations 2014b). The SEEA EEA TR therefore offers several suggestions to bridge the gap between accounting and economics when it comes to valuation.

A subset of valuation methods developed in environmental economics does not include consumer surplus and has therefore been deemed appropriate for SEEA EEA. SEEA

EEA TR (United Nations 2017, Table 6.1) provides a list of valuation techniques that are accounting compatible:

- Production, cost and profit function techniques addressing separate provisioning, regulating and cultural ecosystem services;
- Hedonic techniques, which can estimate the marginal contribution of a bundle of ecosystem services/amenity attributes on house prices; and
- Methods that provide information about expenditures such as defensive expenditures and travel cost where information in the methods is used to estimate a market exchange value.

While national accountants typically use cost-based techniques (e.g. replacement cost), such techniques are only supported within the field of environmental economics if, "the alternative considered provides the same services; the alternative is the least cost alternative and if there is substantial evidence that the service would be demanded by society if it were provided by the least-cost alternative" (Barbier 2012, p. 180). These are relatively strict conditions.

Further research is needed to develop and test valuation techniques that reflect exchange values and hence exclude consumer surplus for non-market ecosystem services (Hein et al. 2015). The challenges of valuing ecosystem services without a market price while still being consistent with SNA, and while providing complementary information to support policy assessment, is one of the topics that is under testing and development in SEEA EEA.

Specifically, SEEA EEA TR proposes to develop methods where non-market valuation studies that originally were meant to derive values that include consumer surplus may later be used to derive the demand curve that would have existed if there was a marked for the good in question. Through combining such a demand function with the supply function for the ecosystem service or benefits one may be able to derive the exchange value. In this step, one would also have to make assumptions about the institutional arrangement for the exchange (see also discussion in Box 5.1 above). Here one might have to try to evaluate as realistically as possible what the institutional arrangement would have been had a market existed. Developing such credible provision scenarios is one of the strengths of stated preference methods when they are conducted to state-of-the art standards. This information combined with a supply curve for the ecosystem service could yield information about the exchange value of the ecosystem service or benefit. Caparros et al. (2017) provide an example of how this method may be put into practice.

In Boxes 5.3 and 5.4 below we show how one could use restoration cost and contingent valuation methods, normally considered inappropriate or incompatible with accounting standards, along the lines of the thinking above to arrive at estimates of exchange values that could be decision-relevant and fit for accounting. The first example discusses the restoration costs of city trees as basic of exchange value and how to avoid double counting (Box 5.3). For an application of ecosystem service valuation for ecosystem accounting in a developing country context that includes provisioning, regulating and cultural services, see e.g. Sumarga et al (2015).

Box 5.3 Use of restoration costs for replacing city trees

Restoration cost refers to the estimated cost to restore an ecosystem asset to an earlier, benchmark condition. The SEEA EEA Technical Recommendations suggest that the methods are likely to be inappropriate since they do not determine a price for an individual ecosystem service, but may serve to inform valuation of a basket of services. Accounting incompatibility in this case is due to an increased risk of double counting when ecosystem services cannot be identified separately, and instead are valued as a bundle associated with a specific ecosystem site or green structure. The valuation method is nevertheless useful in municipal policy and can meet accounting requirements under special conditions. For example, in the city of Oslo, restoration costs of city trees are calculated as a basis for a compensation fee to be paid by parties responsible for damaging trees on public land. The replacement cost is adjusted for the age, health and physical qualities of the tree. The compensation cost is in many cases absorbed as a transaction cost of property development when destroying a tree is unavoidable. As such this is an exchange value, although it has been set through regulation rather than the market. Regarding the risk of double counting, this may be avoided by not including municipal trees in other valuation models (e.g. hedonic pricing models).

Source: Barton et al. (2015).

Box 5.4 Use of contingent valuation to assess cost-recovery-based maintenance of city trees

Contingent valuation is based on survey responses to questions about willingness to pay for ecosystem services and is used to estimate economic value for awareness raising purposes, or as input to benefit-cost analysis. The SEEA EEA Technical Recommendations suggest that using values directly from the method is inappropriate since it measures consumer surplus rather than exchange values. However, as the Technical Recommendations suggest, it is possible to estimate a demand curve from stated preference studies, and that this information may be used in forming exchange values for ecosystem services. As an example, the contingent valuation method was used in Oslo to obtain the willingness to pay a municipal fee for maintaining the density of public street trees. Aggregate willingness to pay across Oslo's population was estimated at 60 million NOK/year for maintaining or increasing street trees across the city. By comparison current municipal costs for maintaining trees in municipal parks and streets is only 12 million NOK/year. While these contingent valuation estimates cannot be used directly to estimate the accounting value of current street trees, the information is useful as decision support and for determining a financially feasible level of supply. Municipal utility services such as water and waste management are charged according to the cost recovery principle (i.e. no producer surplus). The contingent valuation estimates could be used to determine the increased level of street tree maintenance possible if the stated amount was actually charged to households following a cost recovery principle. Future increased supply – here increased maintenance of city trees – might be based on the findings from this contingent valuation study. The contingent valuation identifies feasible cost recovery fees per household and the maximum future maintenance costs that are feasible. While not determined by a market transaction, a public utility fee for maintenance costs of street trees should be accounting compatible as it is a service transaction price (although, as in nature, public utilities are rights-based, or technically difficult to withhold even if no payment is forthcoming from the user).

Source: Haavardsholm (2015).

The second example shows how a contingent valuation survey of people's willingness to pay to maintain or increase the density of street trees can be combined with the costs of supply, to arrive at an exchange price that may be deemed acceptable for accounting purposes (Box 5.4).

The SEEA EEA TR further proposes as a way to determine the most suitable valuation method to use for accounting purposes, to identify so-called "channels" (Atkinson and Obst 2017) through which an underlying ecosystem asset provides

Box 5.5 Valuation methods and links to accounting via channels to users

In order to see the relevance of the non-market valuation methods from environmental economics for accounting purposes, it is useful to view the "channels" through which an underlying ecosystem asset ultimately provides benefits to, or affects the well-being of, the users or economic units. SEEA EEA TR (United Nations 2017, Atkinson and Obst 2017) summarizes three such channels:

1. Ecosystem services used as inputs for production (such as pollination for agricultural production).
2. Ecosystem services that act as joint inputs to household final consumption (such as nature recreation that requires time and travel expenditures on part of the household).
3. Ecosystem services that provide household well-being directly. This is an abstract channel that includes non-use values.

These channels have parallels in accounting, in the way GDP is affected either through inputs to existing (economic) production (channel 1) or to final household consumption (channels 2 and 3). The idea is to identify each buyer (producer or household) and seller (ecosystem), and identify valuation methods that can be used to estimate exchange values, under prevailing institutional conditions. Valuation methods can be grouped according to channels in a supply and use context (Freeman et al. 2014). For industry users, for example, provisioning, regulating and cultural services would provide value through channel 1. For households, provisioning services work through channel 1, regulating through channel 2, and cultural through both channels 2 and 3. Once suitable services, channels, users and methods have been identified, the next step is to use the methods to construct an exchange value estimate for the non-market service. There are different ways this can be done, e.g. as illustrated in Boxes 5.3 and 5.4 above.

Sources: Atkinson and Obst (2017), Freeman et al. (2014) and United Nations (2017).

benefits to the users or economic units (see Box 5.5). The next step is then to identify ecosystem services and benefits and respective valuation methods for each service channel and user. Some of the methods will be accounting compatible and some will require adjustments along the lines noted above, to arrive at exchange values.

Even for non-market valuation techniques from environmental economics that are considered accounting compatible, there are still other challenges related to using these methods for valuation.

As spatially explicit accounting frameworks both SEEA EEA and inclusive wealth accounting need spatially explicit valuation of ecosystem benefits and services. There is a lack of studies in general, though in recent years numbers have increased. Many valuation studies are not motivated by policy questions (Laurans et al. 2013). In those cases where valuation addresses policy, some questions tend to come up more often, and some services appear to be more frequently valued than others. Recreation benefits, for example, may be valued more often than some regulating services. This is also due to the complexity of modelling the ecosystems as well as some services and benefits.

Through adopting landscape, or land area, as the basic accounting unit, characterizing the ecosystem as a natural asset is relatively straightforward. To match the accounting units, non-market valuation studies should also be spatially explicit. With increased availability and use of satellite data maps and geographical information systems, and spatially explicit data analysis techniques, the number of valuation studies that are spatially explicit is expected to rise. But at present, SEEA EEA accounting efforts will by necessity rely on benefit transfer based on studies that are rarely spatially explicit in the sense required for accounting purposes. For those valuation results that are available and site specific on some level of spatial resolution, a main challenge, pointed out by Hein et al. (2015), is to transfer values to other sites and scale the estimates to larger areas required for accounting purposes.

To transfer to other sites there must be sufficient ecological and economic correspondence between the study and the policy sites (Johnston et al. 2015; Barbier 2014). The benefit transfer literature offers simple and more advanced (and sometimes more precise) methods for benefit transfer that sometimes use GIS and scaling-up procedures (see e.g. Brander et al. 2012). Meta-analysis requires knowledge of the values of the independent variables for the policy site of interest and assumes that the statistical relationship between the dependent and independent variables is the same between the study and the policy sites. It is not always guaranteed that more advanced methods perform better (Lindhjem and Navrud 2008). It is also important to delineate different ecosystems and services, to avoid double counting (Barbier 2012).

For wealth accounting purposes it is often ideal to have aggregate values of ecosystem services at the regional or national level. If ecosystem services values have been estimated based on case studies at specific sites, one may question whether the target population of such studies will be appropriate for wealth accounting. That is, can the numbers based on a case study in one location be scaled up to a national level? It is not uncommon that local land use preferences differ from the national preferences for land use (see e.g. Lindhjem 2007 on forest services). Differences in preferences for a policy are not unexpected when a policy has a different impact locally than nationally. Local communities which are more affected by a policy may have per capita net benefits that are much greater (lower) than the average per capita net benefits nationally. But the aggregate net benefits at the national level may be much greater (lower) than the local net benefits.

Using a simple physical index of an area, such as hectares, to expand value estimates to another scale may violate basic economic principles such as diminishing marginal utility, changing relative scarcity and substitutability. However, using average per hectare values is often the way scaling-up is done in practice, for lack of information to adjust values for such factors we know from theory and empirical studies should affect values. In some cases average per hectare values for some degree of scaling may work as approximations that in any case are better than no such information.

To track the wealth of a nation the aggregate values of ecosystem services at the regional or national level should ideally be replicated and updated annually. An important use of such information is to track trends over time. But with the scarcity of non-market valuation studies one is forced to use outdated values. Preferences or demand may change over time, for example as incomes increase, people on average tend to prefer to use more cultural ecosystem services. Preferences are shown in some valuation studies to be stable for periods of up to five years, but for periods beyond 20 years this is not the case (Skourtos et al. 2010). Non-market valuation methods have also improved and can hopefully provide more reliable estimates than some older studies.

The current SEEA EEA process is geared towards testing the operationalization of the SEEA EEA TR in practical cases and through increased practice to gather experiences that may help solve some of the challenges in deriving exchange values for accounting. One relatively large-scale implementation of SEEA EEA principles is currently under way in the greater Oslo area in Norway (see Box 5.6). The aim is to test how the SEEA EEA framework can identify the economic contributions that urban ecosystems make to the municipal, household and commercial sectors in greater Oslo.

4.4. *Accounting for the value of ecosystem assets in SEEA EEA*

In estimating the expected ecosystem services supply it is important to assess possible trade-offs between different ecosystem services in particular policy contexts; for example, there may be a trade-off between forest recreation and production of timber. When valuing ecosystem assets, it requires aggregation of many ecosystem services under the assumption that the prices are independent (Hein et al. 2015).

Box 5.6 Ecosystem accounting at municipal level

Figure 5.4 shows the recommended system of accounts in the SEEA EEA (in grey), placed in the context of different municipal uses of information compiled for accounting. The framework emphasizes the need at the municipal level to base decisions on available information on value of ecosystems. The valuation methods used – whether exchange-based or consumer surplus based – depend on the type of policy question at hand. Information stemming from different valuation and indicator methods is complementary and can be triangulated. This approach has been called integrated or plural valuation (Jacobs et al. 2016), exploring the role of SEEA EEA as a contribution to "considering ecosystems through multiple analytical lenses." Ecosystem accounting within such a plural valuation approach is being tested at the municipal level within the metropolitan area of greater Oslo, Norway. Local and city governments already make use of land use mapping and thematic environmental and socio-cultural indicators to inform impact assessments, municipal planning and zoning. The URBAN EEA project is testing SEEA EEA recommendation on how to identify the economic contributions that urban ecosystems make to the municipal, household and commercial sectors in greater Oslo. Ecosystem accounting offers a complementary set of indicators to municipal government aimed at making fragmented urban nature and blue-green infrastructure more

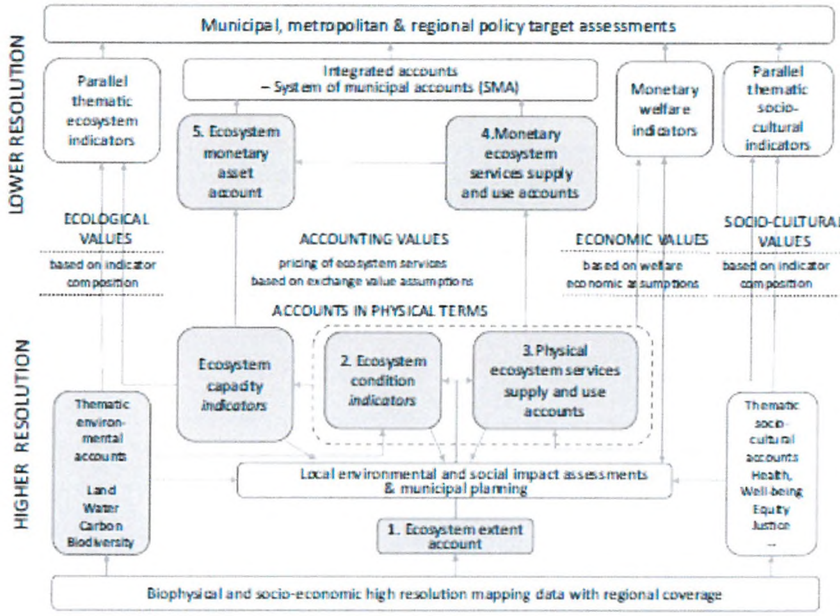

Figure 5.4 Conceptual framework for municipal experimental ecosystem accounting

Source: Based on Barton et al. (2017).

visible in city planning. The project has found that characteristics of urban landscapes may limit the scope of monetary ecosystem accounts in the assessment of municipal policy targets. Urban green structures can be small and hard to identify in GIS, but still be locally valuable. Remnant and constructed urban nature is highly spatially fragmented, mixed-use density is high and highly localized. This makes it challenging to identify marginal values of particular green space qualities and ecosystem services from transactions in the property market. Municipal utilities such as water supply, rainwater management, sewage treatment and solid waste management operate according to cost recovery, meaning that the residual resource rent attributable to ecosystems is zero. Recreational time use in neighbourhood public spaces is very high relative to travel expenses to use the areas, leaving little trace in market transactions. Given these and other challenges of valuation urban ecosystem services (Gomez-Baggethun and Barton 2013), urban EEA aims to provide municipal government with a suite of spatially explicit indicators of accounting compatible exchange value, as well as parallel indicators of ecological, welfare economic and socio-cultural values that are at stake across a cityscape.

As discussed in the Technical Recommendations, while the link between physical flows and provisioning services is quite tangible, the same may not be the case for regulating and cultural services. The supply of these services depends on factors that often are not stable over time such as vegetation, management regimes and pollution levels. Further, one may have limited information about the capacity of the ecosystem to supply the service over time. Finally, for cultural services such as enjoying biodiversity and aesthetic aspects of nature, it may be difficult to identify and describe in general terms the specific link between the condition of the ecosystem in physical terms and the supply of cultural services. Hence, indicators for cultural services require the most further development at this stage, according to the Technical Recommendations (United Nations 2017, paragraph 7.16).

For integration of ecosystem asset accounts with national accounts, the SEEA EEA TR states that consistency with the exchange value concept in SNA, one also should use the market-based discount rates. Estimating using a variety of discount rates to demonstrate the sensitivity of the estimates is recommended. For a more thorough discussion on the application net present value (NPV) for natural resources see SEEA CF (United Nations 2014a, section 5.4).

The life (duration) of the ecosystem asset depends on how it is being used. If use is sustainable then one can assume an infinite asset life. But some ecosystem asset uses can be unsustainable and this will limit the asset life. But even in cases where the asset life is assumed to be infinite, discounting incomes at a high rate may cause the present value of incomes to be negligible after two or three decades. Thus, the decision about discount rate and asset life are not independent. Since there is no a priori preferred asset life, the SEEA EEA TR highlights the need for sensitivity analyses on the asset life and the discount rate.

In finding NPV values, one must recognize that the expected future flows of ecosystem services for an ecosystem asset is affected by the ecosystem condition, which again is affected by the use of ecosystem services. The nexus between use and condition of an ecosystem leads us to the concept of ecosystem capacity. Hein et al. (2016) define the concept of ecosystem capacity for accounting purposes as "the ability of an ecosystem to generate an ecosystem service under current conditions and uses at the maximum yield or use level that does not negatively affect the future supply of the same or other ecosystem services." Thus, capacity may be thought of as the sustainable use of an ecosystem service for which there is demand, preferably at aggregate scales such as at the landscape level.

The SEEA EEA TR (United Nations 2017) states that "ecosystem capacity is considered a topic of ongoing research but with a very high priority" (paragraph 7.68), and that the "concept of ecosystem capacity is a central one for explaining the ecosystem accounting model and applying the model in practice. This is especially the case in relation to developing information sets that can support the discussion of sustainability" (paragraph 7.33).

Some of the reasons why the concept of ecosystem capacity still is under development is that it involves ecologically complex effects such as threshold effects, resilience, ecosystem dynamics and other non-linear effects. These effects also create challenges for standard valuation (exchange or welfare-based valuations, see e.g. discussion in Farley 2012). In addition, one needs to resolve how to measure capacity in practice.

The SEEA EEA TR discusses issues of the measurement of ecosystem capacity. Ecosystem capacity may be monetized in terms of the NPV of estimates for the future basket of services. To obtain an estimate of ecosystem capacity one needs to have an estimate of the future ecosystem service use that is as close as possible to the actual or revealed patterns of use under the expected legal and institutional arrangements. This implies that the estimated future use does not necessarily reflect sustainable uses. One may then compare the NPV of ecosystem use at capacity to the NPV of the actual use, and determine whether the ecosystem is being used above, below or at capacity. Sustainable ecosystem management ultimately requires managing ecosystems below capacity (safe minimum standards). If the ecosystem is used above capacity, it reduces the opportunity for this and future generations to manage the ecosystem sustainably. A decline in condition of an ecosystem asset as a result of economic and other human activity would in SEEA EEA be considered ecosystem degradation. How to include ecosystem degradation has also to be determined. While ecosystem degradation is clearly related to declining condition, it can be defined more specifically as reflecting either a decline in the ecosystem asset value as measured in relation to the change in the NPV of an ecosystem asset based on the expected flow of services, or in relation to the change in the NPV of an ecosystem asset based on its capacity. For both the concept of ecosystem degradation and for the concept of ecosystem capacity one needs to resolve some practical measurement issues that will also have bearings on how to value ecosystem assets within the SEEA EEA framework.

5. Discussion, conclusion and future directions

SEEA and its developments are seen as an important step on the road to wealth accounting (Perrings 2012). We have discussed how the accounting framework SEEA EEA is currently moving towards developing operational solutions to important challenges related to monetary valuation as discussed in the SEEA EEA TR (United Nations 2017).

The requirement only to permit exchange values in SEEA EEA is motivated by the goal of compatibility with national accounting. This would later make it possible to consistently estimate the asset value of a nation's total capital stock. However, accounting that only includes exchange values will not fully reflect the importance of ecosystem services to society (Remme et al. 2015). For example, risks may be unaccounted for in the exchange values (Hein et al. 2015). Further, capturing the value of many regulating and cultural services with exchange value methods will remain a challenge. Further research and testing, is necessary in order to integrate values into an ecosystem accounting framework that is useful for policy assessment (e.g. Remme et al. 2015; Hein et al. 2015).

Another challenge with using exchange values for ecosystem services is that a large share of existing estimates of non-market ecosystem services are in the form of willingness to pay, which includes consumer surplus (i.e. a welfare-based approach) and not in the form of exchange values. However, research on how to derive the exchange value from welfare-based studies is ongoing (see e.g. Caparros et al. 2017; Day 2013; United Nations 2017).

Like SEEA EEA, inclusive wealth accounting is mainly constrained by the lack of shadow prices for ecosystem assets, and "there is insufficient experience with the calculation of these shadow prices at the scale required for accounting" (Hein et al. 2015, p. 90; Barbier 2013). Dasgupta and Duraiappah (2012) recognize that we can never get the shadow prices "right." Instead, we can simply try to estimate the range in which they lie. Given these challenges, empirical studies in the inclusive wealth framework have also resorted to using market prices (exchange value) for those ecosystem services/benefits that have market prices. However, research is also ongoing to find better estimates of shadow prices (Fenichel and Abbott 2014). The next best solution, suggested by Dasgupta and Duraiappah (2012, p. 26), is to use "willingness to pay shadow prices," while recognizing that these prices may not capture threshold effects of an ecosystem.

Both for SEEA EEA and the inclusive wealth framework there is increasing interest among researchers to tailor valuation studies for natural and ecosystem capital accounting, as recommended by Tallis et al. (2012). This would be the ideal situation, since the need for and challenges of benefit transfer and scaling-up would be reduced. For both wealth accounting frameworks, it may be difficult to account for non-use values such as existence values and other subtler cultural services/benefits, even though we know from many studies that such benefits can be important for people's welfare (Lindhjem et al. 2015). If the goal is to demonstrate the importance of an ecosystem service, one may have to use other indicators of value (see Box 5.6 and Barbier 2014) when direct valuation of the ecosystem service fails. This could be due to lack of data, difficulty in defining institutional arrangements that mimic exchange values or because accounting compatible values capture only a very small part of welfare (Jacobs et al. 2016).

Inclusive wealth accounting is a developing accounting framework for both human, natural and ecosystem capital with the goal of demonstrating the importance of these types of capital to human well-being. Since the focus is welfare-based one needs shadow values of the capital stocks, and estimates of shadow values are hard to come by. SEEA EEA specializes in ecosystem accounting using a national accounting framework. While the national accounting framework implies some restrictions, such as the use of exchange values, developing ecosystem accounts based on an existing accounting framework may be quite helpful. The SEEA EEA has developed concrete solutions to several accounting challenges and contributed to operationalize measurement. Furthermore, the need to complement the SEEA EEA framework with ecosystem capacity accounts to better track sustainability of ecosystem use has been recognized.

On the other hand, inclusive wealth accounting emphasizes intergenerational welfare and is not restricted by national accounting standards. However, calculating the total value of natural capital for inclusive wealth calculations is also quite difficult and may go beyond what can currently be achieved. A more achievable goal might be to evaluate the marginal value of natural capital, which is how a small change will alter the present value of the flow of services. Further, in order to find the present value of future flows of ecosystem services one will need models to estimate the impact of changes in natural capital on the provision of ecosystem services. One also needs to predict the future prices and determine the appropriate discount rate. Other related challenges include issues related to resilience and thresholds of ecosystems.

Finally, equity is also a crucial part of sustainability. Solely focusing on aggregated numbers at the national level may not be the best way to evaluate sustainability because numbers at the national level might mask the impacts at the local level as well as inequalities among income groups in the current generation, and across generations. Thus, inclusive wealth accounting should also address the spatial and temporal distribution of wealth.

In the end, if attempting to account such complex assets as ecosystem assets, no matter which accounting system one applies, it is important one is aware of the assumptions and the limitations of the accounting framework and the benefits of an accounting framework that can be applied consistently over time.

Notes

1 See also the recent developments on a so-called Integrated system of Natural Capital and ecosystem services Accounting in the EU (KIP INCA) (La Notte et al. 2017). This system aims to work according to the SEEA EEA system and to further develop this based on EU experiences.

2 Note that in the ecosystem accounting framework biodiversity is treated as a component of the ecosystem asset rather than as an ecosystem service in its own right (United Nations 2017). In addition, biodiversity is also included in standalone thematic accounts.

3 Data collection started in many countries when ecosystems were already at a highly modified, depleted state. Hence, this view of the references condition has its problems.

4 It is worth noting that the international database of valuation studies, Environmental Valuation Reference Inventory (EVRI), has just recently been opened for the public: www.evri.ca

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