Chapter 28
Coastal-Marine Ecosystem Accounting to Support Integrated Coastal Zone Management

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Significance Statement Coastal and marine ecosystems face historical deterioration worldwide. This negatively affects the provisioning of ecosystem services to society. The UN has recently approved a statistical standard for ecosystem accounting to measure the contribution of ecosystem services to the national economy and track changes in the value of naturel capital. It has been suggested that ecosystem accounting can also be used to support policy and management at regional and local level. This study presents an exploratory assessment of ecosystem accounting's role in supporting integrated coastal zone planning using the Oslofjord in Norway as a case. We discuss how ecosystem accounting, and ecosystem service use and monetary accounts in particular, could be useful to support various aspects of integrated coastal zone planning, nature conservation and financing.

Keywords Ecosystem accounting · Coastal and marine ecosystems · Integrated coastal zone management · Oslofjord

1 Introduction

Ecosystem accounting aims to identify the contribution of ecosystem services to the economy and the impacts on ecosystems from economic activities (UNCEEA, 2021). In March 2021 the UN Statistical Commission adopted the System of Environmental Economic Accounting Ecosystem Accounting (SEEA EA) providing a statistical standard for physical ecosystem accounts and their integration in reporting for the national accounts.[1] The expectations are high: UN secretary-general

[1] https://www.un.org/en/desa/un-adopts-landmark-framework-integrate-natural-capital-economic-reporting

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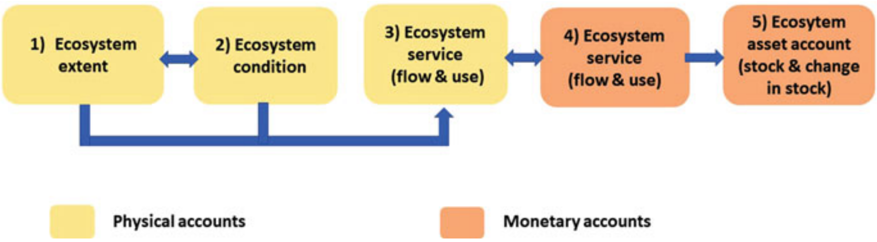

Fig. 28.1 The five core accounts in the System of Environmental Economic Accounting Ecosystem Accounting (SEEA EA). (Adapted from UNCEEA, 2021)

António Guterres called it "(. . .) a historic step forward towards transforming how we view and value nature. We will no longer be heedlessly allowing environmental destruction and degradation to be considered economic progress." SEEA EA aims to periodically report on (1) physical ecosystem extent, (2) biophysical indicators of ecosystem condition, (3) biophysical flow of ecosystem services supply & use, (4) monetary valuation of ecosystem services flow, and 5) the monetary value of ecosystem assets.[2] The physical accounts (1–3) are a UN statistical standard, whereas the monetary accounts (4–5) are recommendations that follow recognized national accounting practices, subject to further testing before they are adopted as a standard (Fig. 28.1).

As statistical standards that is compatible with the system of national accounts, SEEA EA provides a tool to identify ecosystems' contributions to the national economic development as measured by e.g. GDP. Application in support of policy development at the national level has been a key motivation for the framework. Guidance on thematic accounts for e.g. climate, biodiversity, oceans and urban areas is also provided. The novelty of Ecosystem Accounts (EA) relative to previous Environmental and Economic Accounts, is that reporting is both tabulated and mapped. As the data collected are spatial, it may also be used at sub-national geographic levels of aggregation. SEEA EA at sub-national level could aim to assess multi-period change in habitat extent and condition in a region or municipality, assess effects on ecosystem services supply, correlate with past implementation of local policies on the ecosystems, in order to support future decision-making on financing of measures (UNCEEA, 2021). Accounts provide a consistent historical reporting, in order to support forward looking methods and decision-support tools such as cost-benefit analysis, risk assessments, scenario analysis and trade-off analysis (UNCEEA, 2021). A global ocean account partnership[3] has been formed to facilitate ocean ecosystem accounting. However, coastal and marine ecosystem accounting is still in its infancy (Chen et al., 2020). The main interest so far has been to consider the ocean as a contributor to national wealth. However, many decisions affecting the oceans are taken at lower levels than the national. Decisions in the

[2] Discounted flow of benefits from ecosystem services

[3] https://www.oceanaccounts.org/

coastal zone affect the marine environment, challenging spatial accounting boundaries. Thus, there is a need to develop accounting methods that can provide inputs to regional level coastal-marine spatial planning, integrated coastal zone management and resource management. In this chapter, we study the preliminary efforts to integrate ecosystem accounting into a plan for the Oslofjord in Norway. The plan includes the fjord and a 100-meters belt of the shoreline, thereby sharing characteristics of integrated coastal zone management (ICZM). The study is based on the existing ecosystem service literature and public hearing documents for coastal zone planning of the Oslofjord. Ecosystem accounts that can be used to support ICZM should have a different spatial scale than that mentioned in the thematic ocean accounts. The chapter is among the first to assess how ecosystem accounting can provide decision-support to Integrated Coastal Zone Management (ICZM).

Several recent systematic reviews have called for further research on processes that may facilitate uptake of physical ecosystem service assessment and monetary valuation in decision-making (Laurans et al., 2013; Lautenbach et al., 2019; Mandle et al., 2021). Ecosystem accounting partly identifies plural values through spatially explicit biophysical as well as monetary indicators of ecosystem services. This resonates with calls for integrated valuation and value pluralism in decision making (Jacobs et al., 2016; Pascual et al., 2017). The Convention on Biological Diversity (CBD) refers to the valuation methods in The Economics of Ecosystems and Biodiversity (TEEB; Kumar & Martinez-Alier, 2011) and SEEA EA as tools for achieving post-2020 targets of integrating biodiversity valuation in planning and reporting (CDB, 2020). The Dasgupta Review (HM Treasury, 2021) identifies the need for using multiple valuation methods reflecting inclusive wealth in planning and policy.

2 Integrated Coastal Zone Management in the Oslofjord

Figure 28.2 shows the Oslofjord and the municipalities located along the fjord. It is Norway's most populated fjord with about 1.6 million people (1/3 of the national population) and has experienced significant population growth in the recent decades. The Oslofjord faces historical deterioration of ecosystem condition. The more densely populated inner fjord has the least amount of publicly accessible coastline in Norway due to private property development (NEA, 2019). Coastal water chemical condition is "poor" and ecological condition "moderate" in most of the inner fjord according to Water Framework Directive (WFD) standards (NEA, 2019). Stocks of two coastal cod species historically important for commercial and more recently for recreational fishers have plummeted during the 1990s without recovering, resulting in fishing bans (NEA, 2019). Seagrass has declined in inner fjord and kelp has been lost in outer Oslofjord (Christie et al., 2019; Moy & Christie, 2012). There are increasing conflicts of interests among economic developments along the coastline, nature conservation and the recreational use of the fjord. In a public hearing in 2018, the priority environmental problems identified by the stakeholders

Fig. 28.2 The Oslofjord and activities around the fjord. (**a**) map of Norway (naturbase.no), (**b**) Skyline view from the inner Oslofjord, (**c**) A family in their sailing boat in the fjord, (**d**) Camping site on an island in the outer Oslofjord, (**e**) Map of the Oslofjord (naturbase.no), (**f**) A sign marking the coastal trails, (**g**) People fishing along the fjord, (**h**) Crowded coastal real estates in the inner Oslofjord, (**i**) People bathing in the fjord. (Source: Chen et al., 2019)

included eutrophication of coastal water, coastal real estate development, ship traffic and related accident risks, noise from motorized boats, contaminated marine sediments near harbors, and invasive species such as the Pacific Oysters (Chen et al., 2019).

Due to the importance of the Oslofjord and its deterioration, the Norwegian parliament took the unusual step to request the government to make an Integrated Plan for the Oslofjord (IPO). The first version was published by the Norwegian Environmental Agency in the end of 2019. The proposal covers the inner and outer basins including a 100-meter zone on land, which has a peculiar legal status in Norwegian planning. The goal of the plan is to facilitate cross-sectoral collaboration and to achieve ecosystem-based management of the fjord.

As an input to the planning, the Agency commissioned a knowledge synthesis on the values of the Oslofjord (Chen et al., 2019). The first version IPO plan recognizes the importance and the challenges of ecosystem accounting to support coastal management. Current Norwegian coastal-marine monitoring programs focus largely on ecosystems' extent and conditions, but hardly at all on identifying the supply and use of ecosystem services. Operationalization of ecosystem service approaches remains low 15 years after the Millennium Ecosystem Assessment, both in (i) planning according to the Norwegian Planning and Building Act (Ellefsen et al., 2020), (ii) spatial planning in coastal waters (Kvalvik et al., 2020) and (iii) environmental impact assessments in coastal areas (Hersoug et al., 2019). A lack of guidance and tools on how to use ecosystem service valuation in local planning is known to be a barrier to adopting ES in the coastal planning (Marre et al., 2016), partly due to lacking information platforms to facilitate coordination (Kvalvik et al., 2020). This is a knowledge gap recognized by the IPO (NEA, 2019).

3 Ecosystem Accounting of the Oslofjord (Selected Examples)

The knowledge synthesis on values of the Oslofjord estimates economic values of various ecosystem services including provisioning, regulating and cultural services. The monetary values for various ecosystem services in the Oslofjord were compiled using existing literature. Table 28.1 shows a bridging table between accounting compatible exchange values and welfare values of ecosystem services, reporting valuation results for provisioning, regulating and the cultural services that could be valued with available data.

A bridging table is recommended by the SEEA EA as a way for statistics compilers to reference welfare values *complementary* to the national accounts (p.252, ch12). Welfare values for a regulating and cultural services are often larger than exchange values because they are *unrealized* (p.252, ch12) by existing economic institutions which are the basis for historic accounts. Welfare values are complementary decision-support because they can be internalized in prospective policy analysis. The light green and brown shadow in Table 28.1 (the first row) indicate methods that are compatible with SEEA EA standard, while those with light

Table 28.1 Bridging table between accounting and welfare value of ecosystem services: valuation methods and accounting compatibility

Ecosystem service	Sector interest	Inner Oslofjord	Outer Oslofjord	Market price (mill. kr./yr.	Time value (mill. kr./yr)	Maintenance cost (mill. kr./yr)	Capital cost (mill. kr./yr)	WTP (mill. kr./yr	Cost of measure (mill. kr./yr)	WTP (mill. kr.)	Cost of measure (mill. kr.)
		assessed									
Provisioning	Commercial fishing	yes		25							
Regulating	Carbon storage kelp, seagrass	insig.	yes	10							
Cultural services	Tourism	yes		209							
	Bathing and walking, market substitute	yes	yes	10657							
	Bathing, walking & boating	yes	yes		25718						
	Boating, maintenance	yes	yes			2595					
	Boat and fjord access	yes	yes				2104				
	Residential view and access amenities	yes	yes				1500				
	Recreational fishing	yes						312			
	Water quality for recreation	yes	yes					4350			
Costs of measures	Sewage treatment	yes	yes						2730		
	Sediment remediation	yes	yes							1279	
	Oil spill remediation	yes	yes							1546	
	Sediment remediation	yes	yes								406

Note: Market price – Values estimated with market prices include: Time value – opportunity cost of time, Maintenance costs – expenses related to keep up and maintain the boats, Capital costs – investment costs, WTP – Willingness to pay, Cost of measure – direct economic costs related to measures to improve sewage treatment and soil remediation; Kr. = Norwegian krone. (Source: Adapted from Chen et al., 2019)

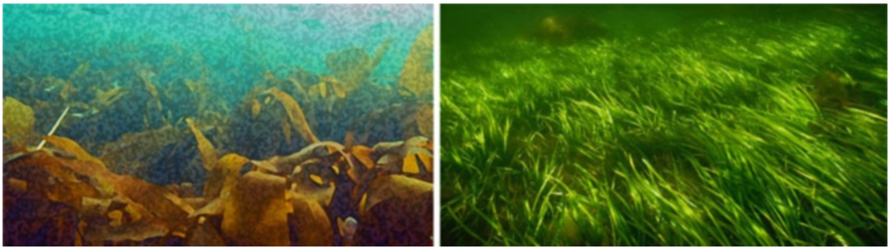

Fig. 28.3 Kelp forest (*Laminaria Hyperborea*) and seagrass (*Zostera marina*). (Foto: NIVA)

red are not. For example, cost of sewage treatment and sediment remediation are estimated using market price and are accounting compatible. On the other hand, beach habitat value is estimated using the willingness-to-pay to avoid oil spill remediation which as a welfare measure is incompatible. Nevertheless, both approaches offer complementary perspectives on values of the Oslofjord which are relevant for policy and planning.

The value of provisioning services is estimated using the market price of commercial fishery. Recalling the historic decline in fish stocks, there is only limited commercial fishery in the outer Oslofjord and the market value in 2019 was relatively small. For regulation services in Table 28.1, the focus is on the blue carbon regulating services (Chen et al., 2019). The seagrass and kelp forest have suffered degradation in the inner Oslofjord due to for example eutrophication and siltation. Figure 28.3 shows the kelp forest (*Laminaria Hyperborea*) and seagrass (*Zostera marina*) that can be found in the Oslofjord.

Coastal monitoring programs have followed trends in the extent of the two habitats. Recent research has focused on the carbon regulation function of the two habitats (e.g. Frigstad et al., 2021). The values of carbon regulating services were calculated directly from the extent data using the social cost of carbon and carbon price from the EU Emission Trading System (ETS) market. While both approaches are consistent with SEEA EA exchange value concepts, the value from EU ETS market is much lower than the value estimated by social cost of carbon.

Cultural services have the highest monetary values of all ecosystem services reviewed by Chen et al. (2019). Examples of recreational activities along the fjord are shown in Fig. 28.1. The value for tourism is estimated by cruise payments and the cabin fees. The recreational values for coastal trails, boating and beach bathing were calculated using the market substitutes and the opportunity cost of time. The value estimated from market substitutes for bathing is much higher than the opportunity costs of time in travel and on site. Both methods are SEEA EA compatible, although the opportunity cost of time is subject to strong assumptions about labour-leisure opportunities, so we have reported it separately. For values of recreational boating, investment cost and operational costs are used for motorized boating and the opportunity costs of time are used for non-motorized boats. Value of residential view and access to amenities is calculated using the hedonic property pricing method. The hedonic property pricing method relies on market price for real estate properties with different environmental amenities to determine the implied value or implicit price of the environmental amenities (Champ et al., 2017). Value for recreational fishing is estimated using welfare-based value transfer from the freshwater recreational fishing estimates. Values for improved water quality for recreation were calculated using both sewage treatment costs and welfare-based choice experiment. Choice experiment method is a non-market valuation method. In this case the respondents were asked to choose between various pair of attributes for water quality, water related recreational activities and the payments. The marginal willingness to pay can be estimated for each attribute and for the various bundles of attributes (Adamowicz et al., 1998; Champ et al., 2017). The estimated willingness to pay is a welfare measure.

In the SEEA EA global consultation draft (UNCEEA, 2021), a similar bridge table between accounting and welfare value of ecosystem services is provided (Table 12.1 in UNCEEA, 2021). It assumes that for each service there is only one exchange value compatible method and only one welfare compatible value. It also assumes that ecosystem services can be uniquely identified. A broad lesson from Table 28.1 is that available valuation studies and statistics cover different geographical areas, and portions of cultural and regulating services which are partly overlapping. Different accounting compatible and incompatible valuation methods mean that all estimates cannot be aggregated. Table 28.1 highlights the challenge of standardizing monetary valuation for ecosystem accounting using only available data generalized to the accounting area using value transfer methods. It demonstrates the need for primary valuation methods implemented for the specific purpose of compiling accounting compatible monetary values. Crucially, this includes monitoring of physical supply and use, and in particular recreation, given indications of its high value in the Oslofjord.

4 Uptake of Ecosystem Accounting in ICZM of the Oslofjord

4.1 Ecosystem Accounting Purpose, Scale and Resolution

EA has high requirements for spatially explicit periodic data. While marine ecosystem extent data is available spatially, much of the ecosystem data still needs to be downscaled at finer geographical levels. In general, marine ecosystem may have larger uncertainties related to regime shifts and more spatial diffusion through currents, resulting in non-linear supply of ecosystem services across larger areas than for terrestrial ecosystem. Ecosystem based management has aimed to tackle the fragmented management across administrative borders. This results in institutions and cross regional collaboration that can integrate coastal-marine systems (i.e. ICZM including land-sea interactions) in a larger unit to manage the dynamic and spatially diffused ecosystem.

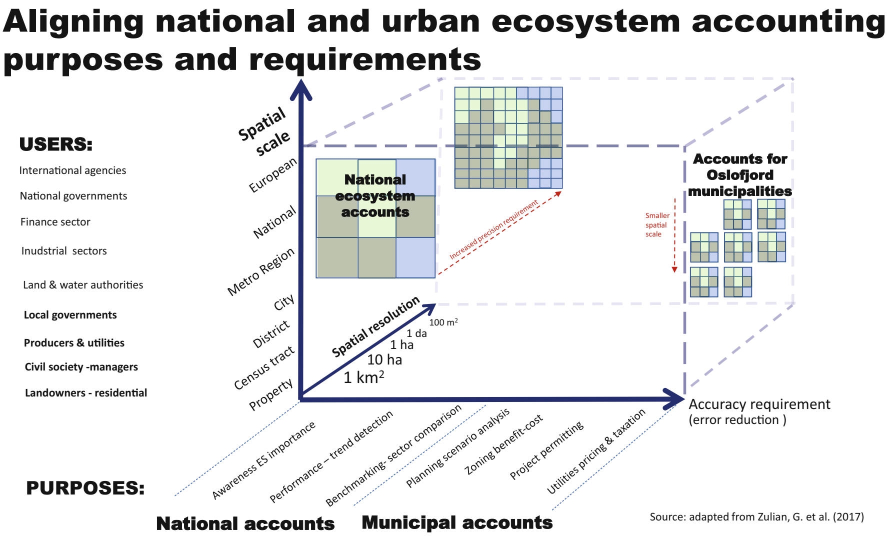

Fig. 28.4 Precision differential between biophysical and monetary accounts. (Source: adapted from Zulian et al., 2018)

The need for spatial data and its resolution varies across regions, users and purposes of ecosystem accounting. Figure 28.4 outlines how different purposes of ecosystem accounts and their users may have different requirements for reliability of ecosystem accounts. It illustrates that costs of accounting information increase with scale, resolution and reliability requirements of purposes and users. Reliability requirement is understood here as the requirement to reduce measurement and modeling error to a level where e.g. trends in ecosystem service flow can be identified with statistical confidence. Reducing measurement and modeling error requires more data and effort, which implied higher information costs.

Figure 28.4 illustrates our overall experience in the Oslofjord – likely to apply to many coastal sites – that there is a precision differential between existing data on physical ecosystem extent and condition and available valuation estimates. Figure 28.4 also illustrates that landowners will require higher resolution of biophysical or monetary values when making plans for their properties, compared to municipal master plans or higher levels of planning and policy making. For example, the real estate agency will need values for the area of the new estate development, while the municipality will focus on the coastal zones that are located within their administrative area. Real estate developers and costal municipalities will need relatively high-resolution data for public purchase of private estate in the coastal zones. The requirements for the resolution and scale vary with other policy analysis purposes (I-III) to which ecosystem accounting may be applied. While a primary purpose of ecosystem accounting is to identify annual trends in the flow of ecosystem services, temporal resolution of remote sensing-based and environmental monitoring data is often greater. On the other hand, slow ecosystem change may not be detectable at high temporal and spatial resolution. The resolution of physical use and economic data is usually lower than that of environmental monitoring. Therefore, the choice of accounting resolution therefore needs to strike a balance between the benefits and costs of increased resolution for physical and monetary accounts, relative to the reliability requirements of the specific accounting purpose.

4.2 Transaction Values Versus Welfare Values

Grimsrud et al. (2020) argue that the ecosystem extent and condition, ecosystem service use, transaction values and economic welfare indicators of ecosystem service can be regarded as parallel channels that contribute to the regional planning, or in the context of this paper marine spatial planning and ICZM in the marine context. Table 28.1 shows that transaction values, estimated using market price, can be much lower than the welfare values derived from non-market valuations such as choice experiments and contingent valuation. Only transaction values are compatible with core accounts in the SEEA EA standards. As not all ecosystem services are traded in the markets, the bridging Table 28.1 shows that transaction values measured as ecosystem contributions to the economy (in the sense of SNA) represent only a partial valuation of ecosystem service contributions to people. From the perspective of ICZM it is important to allow for value pluralism for decision making, awareness raising and fund raising. The plural values include transaction values-SEEA EEA approach, welfare values, and biophysical and qualitative indicators.

4.3 Uptake of Monetary Ecosystem Accounting in Norwegian Coastal Planning

The IPO, sharing characteristics with ICZM, is an independent and unique strategic plan. The major mechanism for the successful implementation of the IPO is for the national government to engage in close collaboration with the municipalities and counties in the Oslofjord region. Key areas for collaboration have been identified such as outdoor recreation, spatial planning (including planning for habitat conservation and marine protected areas), wastewater treatment, local agricultural management. Collaboration between the three political-administrative levels in Norway (i.e. national, county and municipality, each with various sectorial responsibilities) is institutionalized in two relevant planning systems: the spatial planning and the ecosystem-based management. Spatial planning, involving municipal master plans covering land and sea, zoning plans and building permissions, is primarily the responsibility of the municipalities. Ecosystem-based management of freshwater and coastal waters according to the Water Framework Directive is primarily the responsibility of the counties which work through water basin authorities. In these plans, political decision-makers balance diverse interests, give guidance for future developments and adopt action plans. Thus, ecosystem service valuation must be integrated into these types of plans.

There exist several shared databases in Norway for planners providing information about species, habitats and the conditions of ecosystems such as naturbase[4] and vann-nett[5] Ecosystem accounting requires improved data about ecosystems and their condition and a new and coordinated effort in Norway also to integrate ecosystem services. EA offers a standardized framework and links ecosystem services to the change of ecosystems over longer time periods. If shared across administrations involved in spatial planning and water management, EA would increase data and information transparency and could enhance the coordination of local and regional policies (Chen et al., 2020). The common and consistent reporting framework of SEEA EA should make it easier to agree on a shared understanding of the ecosystem, which is a topic that often creates conflict.

Better availability of spatially explicit data on biophysical assets will be an important contribution from EA to improved resource management. Environmental Impact assessments and Strategic Environmental Assessment are important tools that would take advantage of this. In Norway, such assessments are mandatory for spatial plans. While environmental and socioeconomic issues are incorporated in such reports, there has been limited consideration of ecosystem services. Norwegian national regulations on environmental impact assessment specified for the first time in 2020 that ecosystem services must be considered. This will be a main policy driver for getting more data about ecosystem services.

Monetary valuation of ecosystem services has not been widely used in coastal and marine decision making in Norway. However, there are many purposes for which monetary valuation (i.e. EA monetary accounts of ecosystem services) would be important. Conflicts between coastal zone real estate development and public access to the coast is one example. SEEA EA has a potential to provide a common data platform to provide information both on biophysical indicators of impacts on the ecosystem and recreational use values, showing negative and positive effects of the new estate development. The municipalities, which are responsible for planning and issuing building permits, could use the information to weight the financial gain from the new estate development and the potential loss of recreational value and use of the public. Where conflicts between public access to the coastal zone and private estates are high, ecosystem use and value accounts will provide decision support on whether to purchase the private estate to safeguard "the coast for all", which is a primary Norwegian policy objective. These accounts could also provide a basis for ecological fiscal transfer from national budget to municipality to support nature conservation at the local level.

[4] https://www.miljodirektoratet.no/tjenester/naturbase/

[5] https://www.vann-nett.no/portal/

Another application of EA monetary supply-use accounts of ecosystem services in coastal planning is to support prospective cost benefit analysis (CBA) of policy measures. This will be useful for instance as a basis for the water management plans which contains an action program with measures to ensure the achievement of good ecological status according to the Water Framework Directive. A key challenge in the Oslofjord is to reduce eutrophication caused by sewage and agricultural run-off. Cleaning of sewage will cost billions of kroner for the municipalities (Table 28.1). Similarly, farmers will incur high costs for building e.g. retention basins or set aside cultivatable land as buffer zones. The monetary supply-use accounts for ecosystem services can provide data on historic costs incurred in sewage cleaning and agriculture run off reduction measures, to achieve past eutrophication levels. Exchange values of measures that were recorded in accounts can be complemented in CBA with the welfare measures of willingness-to-pay to achieve water quality objectives, in order to analyze various prospective policy scenarios.

5 Conclusion

Using the Oslofjord as an example, the study presents an exploratory assessment of the role monetary valuation in ecosystem accounting to support integrated coastal zone planning. The study highlights that ecosystem service use and monetary accounts in SEEA EA has a large potential to support the integrated coastal zone planning of the Oslofjord such as Environmental Impact Assessments, Strategic Environmental Assessments and Cost Benefit Analysis. The requirements on the resolution and scale of EA depends on who is the user of the EA and what are the policy targets. Our study also shows that both transaction values measured as ecosystem contributions to the economy and welfare values need to be considered in the coastal zone planning. We found that available statistics on supply-use of ecosystem services and existing monetary estimates were not designed for ecosystem accounting purposes and could not easily be aggregated. However, comparison in bridging tables of different types of monetary values was still considered useful for decision-support.

With the value transfer approach used by Chen et al. (2019) based on generalizing existing data, exchange values were not spatially explicit - monetary values acted as scaling constants for the biophysical use data. In such cases all the information on spatial variation in ecosystem services is contained in the physical supply-use accounts. As long as monetary valuation is based on simply unit value transfer methods, the information value-added of ecosystem accounting for Norwegian environmental governance is mainly in terms of physical ecosystem extent and condition accounting, rather than monetary valuation of ecosystem services. In the Oslofjord there is a lack of spatially resolved physical monitoring of supply-use of ecosystem services. Finally, monetary accounts compatible with the SEEA EA will require monetary valuation studies that are designed explicitly to be part of regular statistics compilation in support of the Integrated Plan for the Oslofjord.

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