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Bridging the gap between ecosystem service indicators and ecosystem accounting in Finland

Tin-Yu Lai[a,*], Jani Salminen[b], Jukka-Pekka Jäppinen[c], Saija Koljonen[d], Laura Mononen[c,e], Emmi Nieminen[f], Petteri Vihervaara[c], Soile Oinonen[f]

[a] University of Helsinki, Department of Economics and Management, P.O. Box 27, FI-00014, Helsinki, Finland
[b] Finnish Environment Institute (SYKE), Centre for Sustainable Consumption and Production, P.O. Box 140, Mechelininkatu 34a, FI-00251, Helsinki, Finland
[c] Finnish Environment Institute (SYKE), Biodiversity Centre, P.O. Box 140, Mechelininkatu 34a, FI-00251, Helsinki, Finland
[d] Finnish Environment Institute (SYKE), Freshwater Centre, Jyväskylä Office, Survontie 9 A, FI-40500, Jyväskylä, Finland
[e] University of Eastern Finland, Department of Geographical and Historical Studies, P.O.Box 111, FI-80101, Joensuu, Finland
[f] Finnish Environment Institute (SYKE), Marine Research Centre, P.O. Box 140, Mechelininkatu 34a, FI-00251, Helsinki, Finland

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ABSTRACT

In this paper, we examine how progress on ecosystem service indicators could contribute to ecosystem accounting within the scope of environmental-economic accounting in Finland. We propose an integration framework and examine the integration of ecosystem service indicators into environmental-economic accounting with two case studies relevant for Finland: (1) water-related ecosystem services and (2) the ecosystem services of fish provisioning in marine ecosystems. In light of these case studies, we evaluate the relevance of existing Finnish ecosystem service indicators, the data availability for ecosystem accounting in Finland, and the applicability of the System of Environmental-Economic Accounting ö Experimental Ecosystem Accounting (SEEA-EEA) framework to integrate Finnish ecosystem service indicators and other relevant data into environmental-economic accounts. The results indicate that the present ecosystem service indicators can assist in creating a basis for ecosystem accounting, but the indicators require further elaboration to be more compatible with the existing environmental-economic accounting system.

1. Introduction

In recent years, various disciplines have worked to improve the sustainability of coupled human-environment systems. One such contribution is literature in the field of accounting that acknowledges the insufficiency of the System of National Accounting (SNA) in measuring the negative environmental impacts of economic activities (Bartelmus et al., 1991; Boyd and Banzhaf, 2007; La Notte et al., 2017a; Repetto, 1992). Indicators such as gross domestic product (GDP) should be adjusted or supplemented with additional accounts to record the extent, development, and possible overconsumption of natural resources, and to consider negative environmental impacts such as pollution and detrimental use (see, e.g., Bartelmus, 2009; Nordhaus, 2006; Obst et al., 2016). To achieve this goal, two statistical frameworks have been developed to supplement the SNA: 1) the System of Environmental-Economic Accounting – Central Framework (SEEA-CF) and 2) the System of Environmental-Economic Accounting – Experimental Ecosystem Accounting (SEEA-EEA) (UN et al., 2014a,b). Both frameworks include accounting for biological natural resources, but the former system treats environmental assets individually, and the latter one applies a system approach (UN et al., 2014b). Fig. A1 (in Appendix A) presents the scope and differences between SEEA-CF and SEEA-EEA. In this paper, environmental-economic accounting refers to a broad concept that covers the scope of accounting under both SEEA-CF and SEEA-EEA. Ecosystem accounting, in turn, is defined here as the accounting for ecosystem assets and ecosystem services (ESs), as in Hein et al. (2015). Further, following Hein et al. (2015), we define natural capital as environmental assets that provide benefits to humans; ecosystem assets are thus considered as a type of natural capital.

On the European level, two major initiatives, the Mapping and Assessment of the Ecosystems and their Services (MAES) and the Knowledge Implementation Project on the Integrated system for Natural Capital and ecosystem services Accounting (KIP-INCA), play an integral role in developing ecosystem accounting. They attempt to implement the EU Biodiversity Strategy for 2020 by improving the visibility of ESs and by providing support for ES valuation and the integration of ESs into existing environmental-economic accounting and reporting systems (KIP-INCA Report, 2016; Maes et al., 2016). As part

* Corresponding author.
E-mail address: tin-yu.lai@helsinki.fi (T.-Y. Lai).

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of the national MAES process, Finland has recently taken the first steps toward the identification and monitoring of the state and development of ESs and biodiversity by developing National Ecosystem Services Indicators (Finnish ES indicators) (www.biodiversity.fi/ecosystemservices/home; see Mononen et al., 2016). Environmental-economic accounting, however, has deeper roots in Finland (Autio et al., 2013; Hoffrén and Salomaa, 2014). Existing environmental-economic accounts include data on raw material consumption, energy supply and use, waste generation, greenhouse gas emissions, business activities of the environmental goods and services sector, and environmental protection expenditures (Statistics Finland, 2017a). Ecosystem assets and services, however, are not yet part of the Finnish environmental-economic accounting scheme operated by Statistics Finland. Therefore, this paper explores how Finnish ES indicators could be integrated into ecosystem accounting and how future work related to such integration could support the final goal of including ESs into Finnish environmental-economic accounts. For this purpose, two case studies following the approaches provided by SEEA-EEA are elaborated: ecosystem accounting for (1) water-related ESs, and (2) fish provisioning services from marine ecosystems. The latter case study can be regarded as a subset of water-related ESs but is presented separately for the sake of clarity and due to the different methodological approaches used.

The motivations for the choice of these particular case study topics were their high relevance to the economy and the fairly good availability of data related to them. Methodologically, SEEA-CF and SEEA-Water (UN, 2012) provide guidelines for asset (surface water and groundwater stocks), supply, and use accounts for water resources (UNEP et al., 2017). By contrast, SEEA-EEA is applicable to ecosystem accounting, which can consider comprehensive aquatic ecosystems and other water-related ESs in a systematic way. Earlier studies have applied SEEA-EEA to incorporate ES mapping and quantification data into ecosystem accounting from the regional to the continental scale (Khan et al., 2015; La Notte et al., 2017a; Office for National Statistic, 2016; Remme et al., 2014, 2015; Schröter et al., 2014; WAVES, 2017). According to Hein et al. (2015), no case studies existed at the time of publication that would have compiled an ES use account in practice. Later, La Notte et al. (2017a) provided data on actual ES flows of nitrogen retention used by two types of beneficiaries. However, the results from La Notte et al. (2017a) are too aggregated to be integrated into the SNA. In the WAVES project (2017), physical supply and use accounts for the ESs of carbon sequestration and storage water supply in Guatemala were compiled, but monetary use accounts were still missing. Khan et al. (2015) provided an outline of use accounts for freshwater ESs in the UK by identifying the beneficiaries, which can be regarded as the first step toward compiling ES use accounts. The first case study of the present paper aims to take one step forward by developing physical and monetary water ES use accounts compatible with the SNA.

Our second case study demonstrates the provisioning services of three commercially important fish species in the Baltic Sea: herring (*Clupea harengus membras*), sprat (*Sprattus sprattus*) and cod (*Gadus morhua)* (LUKE, 2017). Regarding fish provisioning services, some countries have already compiled asset accounts for fishery resources based on the well-developed SEEA-CF approach (ABS, 2012; Statistics South Africa, 2012; Anna, 2017). These accounts contain data on fish stock, fish catch, and economic activities within the fishery sector. However, understanding their links to whole marine ecosystems requires the application of ecosystem accounting and SEEA-EEA. The literature on marine ecosystem accounting is still scarce. Most of the existing papers focus on coastal ecosystems and emphasize experiments on compiling ecosystem extent and condition accounts (ABS, 2015; Eigenraam et al., 2016; Weber, 2014). Eigenraam et al. (2016) and ABS (2015) included fish provisioning services in their ecosystem accounting, but neither of them estimated the capacity for the ecosystem to provide this ES. In principle, ecosystem capacity connects an ecosystem asset with ESs, as it represents the ability of an ecosystem asset to generate a set of ESs in a sustainable way (UN et al., 2014b; UNEP et al., 2017). In practice, however, SEEA-EEA does not instruct how ecosystem capacity should be measured (UNEP et al., 2017), and the best way to define and measure ecosystem capacity has remained a somewhat controversial issue. In the case of terrestrial ecosystems, Hein et al. (2016) and La Notte et al. (2017a) use ecosystem capacity contradictorily. The former defines ecosystem capacity as a *flow* of an ES that is generated at sustainable level, and the latter defines ecosystem capacity as a *stock* that provides a sustainable ES. *Stock* quantifies the state of an ecosystem at one point in time, while *flow* always has a temporal dimension with several time points. This paper thus reviews both approaches to ecosystem capacity and proposes an operational measurement of this metric for marine fish provisioning services.

To sum up, ecosystem accounting is still at the experimental stage, and many concepts have not yet been operationalized. This study, with its two case studies, serves as a pilot for the evaluation of data availability and the potential ways to integrate Finnish ES indicators into national environmental-economic accounts. Methodologically, SEEA-EEA approaches and the outcomes from the Common International Classification of Ecosystem Services (CICES) and MAES processes are evaluated. This paper is organized as follows: Section 2 provides a general framework to integrate Finnish ES indicators and environmental-economic accounts through ecosystem accounting procedures, with a basic description of ecosystem accounting and the Finnish ES indicators. Section 3 presents the two case studies. Section 4 discusses how the Finnish ES indicators could be improved to facilitate ecosystem accounting and the implementation of the integration framework.

2. Material and methods

This section briefly reviews the Finnish ES indicators and the relevant SEEA-EEA accounts. Fig. 1 illustrates our schematic framework for the integration of Finnish ES indicators into environmental-economic accounts, and Table 1 lists definitions of ecosystem accounts that appear in Fig. 1. The Finnish ES indicators follow the CICES classification system and the so-called Cascade model (Mononen et al., 2016). The use of the Cascade model structured the resulting indicators into four different categories[1]: (1) structure, (2) function, (3) benefit and (4) value (Haines-Young and Potschin, 2010).

2.1. Use of structure and function indicators to develop ecosystem extent and condition accounts

Structure indicators (Fig. 1) define and measure the biophysical prerequisites for functioning ecosystems. Various land cover statistics have been used to link habitat type and ESs in Finnish ES indicators, especially the extent of these habitats across Finland (Mononen et al., 2016). When available, habitat condition data are included in the structure indicators (e.g., water quality or species assemblage) and function indicators (e.g., productivity of an area in a certain unit of time), although spatial ecosystem condition data are still rare. Geographical Information System (GIS) tools and spatial format data are commonly used but are not compulsory for ecosystem extent and condition accounts (Hein et al., 2015; UNEP et al., 2017). Thus, the structure and function indicators in Finnish ES indicators can provide direct input to the ecosystem extent and condition accounts. For some types of ESs, the natural resource stock information in existing environmental-economic accounts can act as an indicator for condition accounts (see the example of water stocks in Section 3.1.2).

[1] In the original Cascade model, there is a fifth category, "ESs", between the function and benefit indicators.