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Research article

Sustainability assessment and causality nexus through ecosystem service accounting: The case of water purification in Europe

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ABSTRACT

The paper builds on the Supply and Use Tables module within the System of integrated Environmental and Economic Accounts - Experimental Ecosystem Accounts (SEEA EEA) developed by the UN. We explore the evolution of Supply and Use Tables from the System of National Accounts (SNA) to the System of integrated Environmental and Economic Accounts - Central Framework (SEEA CF) and then to the SEEA EEA, and we propose a further extension: we propose that ecosystem types should be treated as accounting units able to produce, consume and exhibit changes in regeneration and absorption rates. The implications are first explained in the methodological section and then shown in the application where the water purification service is tested against two major policy issues: sustainability assessment (we show how to assess whether the ecosystem service is used sustainably by comparing the quantification of potential and actual flow) and causality nexus (we quantify the connection between the value of agricultural production and that of the ecosystem service used). The paper highlights how the overall outcomes change when considering different scales. A contrast emerges, for example, between the positive balance at the continental scale, where water purification services appear to be used sustainably (thanks to the high potential flow of Northern European countries) and the negative balance of almost all European countries when considered at a national scale. Taking advantage of the experimental opportunities offered by operating with external satellite accounts, we are able to show how the proposed complementary tables could support policy action.

1. Introduction

A separate analysis of the economy on the one hand and of ecosystem services on the other does not adequately reflect the fundamental relationship between humans and the environment. Only the integration of ecosystem and economic information would allow mainstreaming evidence on ecosystems and their services within public and private decision making (UN et al., 2015). Accounting systems enable the organization of information in an integrated and conceptually coherent manner. This information can then be employed to create scientifically rigorous indicators to be used to inform environmental management and policy choices.

Economic information is provided by the *System of Nationals Accounts* (SNA), a measurement framework that has been evolving since the 1950s to measure economic activity, economic wealth and the general structure of the economy. The strength of the SNA is its robust articulation that allows for a certain deal of flexibility while still remaining integrated, internally consistent and economically complete. However, the SNA framework should neither be overburdened with details nor containing conflicting requirements, likely occurring when a different representation of the economic process leads to different aggregates.

Recognizing a need for flexibility, since its 1993 version (UN et al., 1993) the SNA incorporated the concept of satellite accounts – additional accounts closely linked to the main SNA but not restricted to the same concepts and data. There are two types of satellite accounts: (i) *internal* satellite accounts follow entirely the accounting rules and conventions of the SNA but focus on a particular aspect of interest (tourism satellite accounts are an example); (ii) *external* satellite accounts may add non-economic data and/or vary some of the accounting conventions (e.g. adopt a different production boundary, or consider additional assets). External satellite accounts allow experimenting with new concepts and methodologies in a research context with much wider degrees of freedom (EC et al., 2009).

The System of integrated Environmental and Economic Accounts (SEEA) is a set of satellite accounts; it applies the accounting concepts,

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structures, rules and principles of the SNA to environmental and natural resources in order to integrate environmental information (often measured in physical terms) with economic information (generally measured in monetary terms) in a single framework. The SEEA- Central Framework (SEEA CF) embeds both internal (e.g. environmental protection expenditures) and external (e.g. non-produced environmental assets) satellite accounts. The SEEA CF provides guidance on the valuation of renewable and non-renewable natural resources as well as land within the asset boundary of the SNA (UN et al., 2014a).

In the SEEA CF a distinction is made between the measurement of environmental assets as individual natural resources, cultivated biological resources, land, and the measurement of environmental assets as ecosystem components. A platform for the integration of relevant information on ecosystems and ecosystem services has been recently proposed and supported by the United Nations Statistical Division (UNSD): the System for Integrated Environmental and Economic Accounting-Experimental Ecosystem Accounting (SEEA EEA) (UN et al., 2014a, b; UN et al., 2014b, UN et al., 2017). The SEEA EEA is designed to facilitate comparison and integration with the economic data prepared following the SNA. Specifically, ecosystem information is presented together with standard measures of income, production and wealth. The SEEA EEA is meant for application at a national level (as the SNA) in order to link information on multiple ecosystem types and services with aggregate economic and planning decisions. The SEEA EEA includes only external (ecosystem and ecosystem services) satellite accounts.

In this paper, we adopt an innovative perspective that includes ecosystem as units playing an active role in an economic context. Concepts and structures from other disciplines (environmental science, hydrology, forestry, fisheries, economics, statistics) need in fact to be accommodated within the accounting method, while preserving the SNA as the underlying structure. In our case, we are going to consider ecosystem units providing service flows as institutional sectors and thus to account for what happens to ecosystem units while interacting with economic units. What we want to avoid is to consider ecosystem units merely as providers of inputs to economic sectors and households.

A few previous applications of this perspective have been proposed, most of them at a local scale (La Notte et al., 2011; Busch et al., 2012; Schröter et al., 2014; Remme et al., 2014) and one for Europe (La Notte et al. 2017a, b). All existing studies address methodological and conceptual issues related to the ecosystem accounting procedure and practice. This paper has a more theoretical objective. It aims at exploring in depth and testing the connection between ecosystem services and economic accounts. Specifically, we build on the water purification case studied by La Notte et al. (2017a, b) and, working on biophysical data disaggregated at the national level for 34 countries, we show how they link with national accounts and what information can be obtained by connecting ecological and economic information.

The following section (§2) briefly introduces the main components of the SEEA EEA and focuses on Supply-Use tables, which represent the reference tool for our application. In section 3 the case of water purification and its linkages with economic accounts is presented and explained. In section 4 we demonstrate the critical role played by the scale of analysis in the interpretation of the information provided by environmental accounts. Section 5 offers discussion and conclusions.

2. Integrating ecosystem services and economic accounting: the methodological frontier

The SEEA EEA is composed by two sets of accounts: (i) *ecosystem asset accounts*, quantified through the ecosystem extent account and the ecosystem condition account, and (ii) *ecosystem service accounts,* quantified through Supply and Use tables to be quantified in both physical and monetary terms (Fig. 1). The ecosystem asset account in monetary terms can be compiled by aggregating the Net Present Value (NPV) from ecosystem services Supply and Use tables. An important element in our analysis is that Supply and Use tables are the accounts with a direct connection to economic sectors.

According to SEEA EEA definitions, the stocks in ecosystem accounting are represented by spatial areas, which constitute an ecosystem asset. Flows in ecosystem accounting are of two types: (i) flows within and between ecosystem assets which reflect on-going ecosystem processes (e.g. intra- and inter-ecosystem flows); (ii) flows generated by ecosystem assets and directed to people, i.e. ecosystem services. Flows of ecosystem services may relate either to flows of natural inputs from the environment to the economy or to flows of residuals from the economy to the environment. Ecosystem services provide the link between ecosystem assets and the benefits derived and enjoyed by people. In the SEEA EEA ecosystem services are not ecosystems and are not benefits; they are ecological processes connecting the two.

The SEEA EEA focuses on external (ecosystem and ecosystem services) satellite accounts, whose experimental perspective allows using the SNA articulation to frame, in a consistent economic context, an enlarged production and asset boundary that includes ecosystem units as playing an active role.

2.1. Supply and use tables: from the SNA to the SEEA CF

In the SNA, Supply and Use tables describe the structure of the economy and the level of economic activity by recording all flows of products between different economic units in monetary terms. The Supply table provides records on what is domestically produced by industries and what is imported from the rest of the world. The Use table provides records on the intermediate consumption by other industries, final consumption by households and government, exports and what is not consumed in the current period. The latter includes (i) changes in inventories (additions to inventories less withdrawals), and (ii) changes in fixed capital (e.g. machinery used over a longer period of time to produce other products). Changes in inventories and in fixed capital are recorded as “accumulation”.

All flows are classified by type of product in the rows and by institutional sector (enterprises, households, government and the rest of the world) in the columns. Enterprises are identified on the basis of their principal activity. Institutional sectors are grouped together on the basis of similar objectives, purposes and behaviour. The accounting identity that must be fulfilled is that Supply must equal Use.

Economy and society withdraw flows of mass and biomass from the environment and discharge flows of residuals to the environment. In the SEEA CF Supply and Use tables record, in physical and monetary units, flows of natural inputs and residuals. External satellite accounts are added to the SNA accounts in terms of source of natural inputs and destination of residuals (the column “environment”) and in terms of additional flows to be recorded (the rows “natural resources” and “residuals”). Fig. 2 shows how the SEEA CF complements the SNA for Supply and Use tables.

Although the inclusion of the column “environment” makes it possible to fully account for flows of natural inputs and residuals, the environment in the SEEA CF still remains a passive entity, since its production, consumption and changes in functioning are not recorded (UN et al., 2014a).

2.2. Supply and use tables in the SEEA EEA

In the SEEA EEA the external satellite account concerning the environment stops being purely passive. It is structured according to ecosystem types (e.g. arable land, natural grassland, wetlands, woodland and forests, rivers and lakes[1]) and it provides a series of ecosystem service flows (if recorded according to the CICES classification they would be grouped in ‘provisioning’, ‘regulating and maintenance’, and

[1] For more details, see Figure 3.6 in La Notte et al. (2017b).