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Mapping monetary values of ecosystem services in support of developing ecosystem accounts

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ABSTRACT

Ecosystem accounting has been proposed as a comprehensive, innovative approach to natural capital accounting, and basically involves the biophysical and monetary analysis of ecosystem services in a national accounting framework. Characteristic for ecosystem accounting is the spatial approach taken to analyzing ecosystem services. This study examines how ecosystem services can be valued and mapped, and presents a case study for Central Kalimantan, Indonesia. Four provisioning services (timber, palm oil, rattan, and paddy rice), one regulating service (carbon sequestration), and two cultural services (nature recreation, and wildlife habitat) are valued and mapped in a way that allows integration with national accounts. Two valuation approaches consistent with accounting are applied: the resource rent and cost-based approaches. This study also shows how spatial analysis of ecosystem accounting can support land use planning through a comprehensive analysis of value trade-offs from land conversion.

1. Introduction

Ecosystem accounting is a new area of environmental economic accounting that aims to measure ecosystem services in a way that is aligned with national accounts (Boyd and Banzhaf, 2007; European Commission (EC) et al., 2013; Edens and Hein, 2013). The System of National Accounts (SNA) (European Commission (EC) et al., 2009) provides the global standard for national accounting, and the Central Framework of the System for Environmental Economic Accounts (SEEA-CF) was designed as a satellite account of the SNA (United Nations (UN), 1993; United Nations (UN) et al., 2003), with a global standard for the SEEA-CF adopted in 2012 (United Nations (UN) et al., 2014). Ecosystem accounting involves an extension of the production boundary of the System of National Accounts (European Commission (EC) et al., 2013). This allows the inclusion of a broader set of ecosystem services types such as regulating services and cultural services as well as the natural growth of biological assets such as timber in measures of economic activity. In turn, this allows a more comprehensive recording of changes in ecosystem capital, i.e. the stock of ecosystems that provides a foundation for future well-being, and provides a more complete dataset for environmental policy making (Campbell and Tilley, 2014).

Ecosystem accounting involves approaches to measuring ecosystem capital and comprises the monitoring of ecosystem services flows, the capacity of ecosystems to generate these services, and the condition of ecosystems (European Commission (EC) et al., 2013). Ecosystem condition determines the capacity to generate services, as in the case of standing timber stock, species composition, soil fertility, rainfall, etc. determining the capacity to supply timber at present as well as over time. There remain considerable challenges in implementing ecosystem accounting (Edens and Hein, 2013). One of the main issues is if, how and to what degree ecosystem capital can be valued in monetary terms. In particular, it is still being discussed if ecosystem services flows and the capacity of ecosystems to generate services can be valued in monetary terms in a way that is both consistent with accounting, and that is sufficiently robust for the purpose of accounting (United Nations (UN) et al., 2014). Note that ecosystem condition is not directly connected to human benefits and can therefore not be valued in monetary terms.

Spatial explicitness is a distinguishing property of ecosystem accounts (all with the exception of the land account that provides indications of acreages of land in specific classes potentially combined with ownership information of the land). Both ecosystem services flow, ecosystem capacity and ecosystem condition are spatially heterogeneous (Schröter et al., 2014). There is a wide range of experience with

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mapping the values of ecosystem services (Plieninger et al., 2013; van Berkel and Verburg, 2014; Palomo et al., 2014), and very limited experience with mapping the values of the capacity of ecosystems to supply ecosystem services (Chen et al., 2009; Ericksen et al., 2012). Values have been mapped among others in support of land use planning (Fisher et al., 2011; Ruiz-Frau et al., 2012; Scolozzi et al., 2012) and to monitor the impacts of land use change (Kreuter et al., 2001; Li et al., 2010; Mendoza-González et al., 2012). However, at present, there have been few if any analyses involving the mapping of ecosystem service values in the context of, and aligned with environmental-economic accounting.

The objective of this paper is to examine how ecosystem services can be valued and mapped in a manner aligned with national accounts. In particular, we analyze and map the monetary value of a comprehensive set of ecosystem services in Central Kalimantan province, Indonesia. The novelty of our paper is in the application of a valuation approach consistent with accounting, and in the application of valuation approach to a relatively large area (around 150,000 km^2). In addition, we explore an experimental valuation approach for one specific element of biodiversity: the conservation of orangutan habitat. We selected Central Kalimantan in view of our interest in testing the ecosystem accounting approach in a developing country context, and because Central Kalimantan has been subject to rapid land use change including deforestation in the past decades (Broich et al., 2011; Miettinen et al., 2012), requiring better information on costs and benefits of different land management approaches, and on possible value trade-offs following land conversions. This study includes a specific analysis on the conversion of forests into oil palm in terms of the trade-offs that occur between ecosystem service values.

We value and map seven ecosystem services, following the classifications of Millennium Ecosystem Assessment (MEA) (2003) and TEEB (2010), in a way that permits integration with national accounts. In particular, we distinguish the following services: timber production, rattan production, oil palm production, paddy rice production, carbon sequestration, wildlife habitat, and nature recreation. Although this is not a complete set of ecosystem services generated in the study area, our set is sufficiently large and diverse to explore if and how ecosystem services valuation and mapping can be applied in the context of ecosystem accounting. We explore in our paper if valuation data and analytical approaches are sufficiently robust for integration in accounts, if not, what further steps need to be taken, and what potential other policy applications may exist for spatial maps of monetary values aligned with the system of national accounts.

The outline of the paper is as follows. In Section 2, we describe the valuation methods selected for valuing the seven ecosystem services and how the values are then mapped. In Section 3, we present the monetary value maps and the summary of multiple ecosystem services values in the main land cover classes. In Section 4, we discuss three main issues: monetary valuation and mapping of ecosystem services in support of accounting, challenges in valuation and integrating ecosystem services values in an accounting framework, and value trade-offs and their policy implications.

2. Methods

2.1. Study area

We selected Central Kalimantan province, Indonesia for this study, in view of our interest in testing accounting methods in a developing country context and for a large area. Central Kalimantan is one of the largest provinces in Indonesia, and has been appointed as pilot province for a REDD+ project enhancing data availability of some ecosystem services, in particular those related to carbon. The province covers an area of 153,500 km^2, and is located at latitude 0°45′ North–3°30′ South and longitude 110°45′–115°50′ East. Most of the area (57%) is covered by forest (Fig. 1). This province has experienced rapid land cover change, mostly conversion of forest to other uses, such as oil palm plantations. Based on a comparison of land cover maps of 2000 and 2010 (Tropenbos Indonesia, unpublished), about 14,000 km^2 areas (12.7%) have been deforested during that period. The province has a low population density with an average of 14 people/km^2 and a total population of 2149,896.

2.2. Spatial modeling and mapping of ecosystem services

This papers builds upon previously developed ES models (Sumarga and Hein, 2014), in which physical models for a range of ecosystem services were developed and applied to Central Kalimantan. A range of methods were applied to model and map these services in physical terms including Geostatistics, Maxent, and lookup tables. For this paper, we extend the previous paper with an additional ecosystem service, recreation. We exclude from our paper the service carbon storage since this does not constitute a flow and therefore cannot be included as an ecosystem service in an ecosystem account (even though it is highly relevant for land use planning).

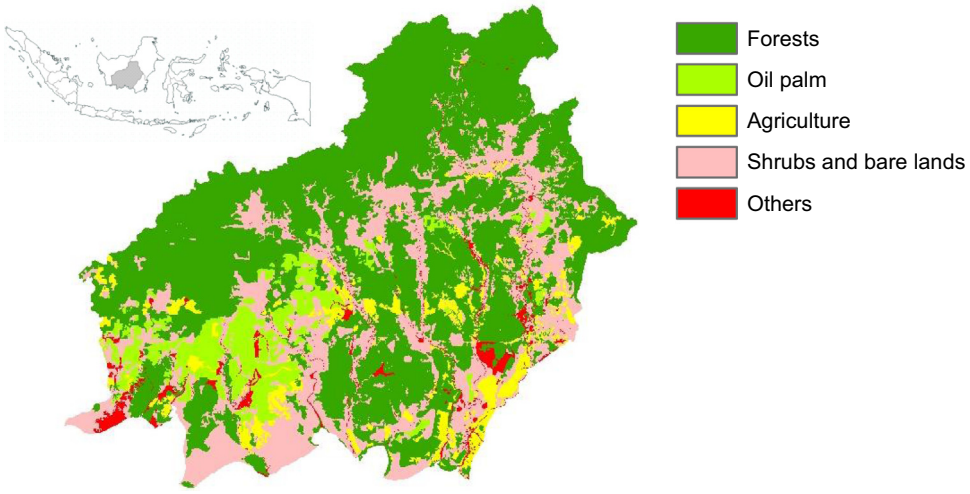

Fig. 1. Land cover map of Central Kalimantan.