Ecological Indicators 55 (2015) 159–171

Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: www.elsevier.com/locate/ecolind

Review

Mapping ecosystem services demand: A review of current research and future perspectives

S. Wolff*, C.J.E. Schulp, P.H. Verburg

Institute for Environmental Studies (IVM), VU University Amsterdam, De Boelelaan 1087, 1081 HV Amsterdam, The Netherlands

ARTICLE INFO

Article history:
Received 6 November 2014
Received in revised form 26 February 2015
Accepted 13 March 2015

Keywords:
Ecosystem service assessments
Indicators
Benefits
Preferences
Land use change
Spatial analysis

ABSTRACT

Mapping the demand for ecosystem services (ES) has received increased attention in scientific research and is seen as a relevant tool to inform conservation planning, land use planning and management. Yet, there is a varying understanding of the concept of ES demand, which has implications on how and where ES demand is being mapped. In this paper we review the current conceptual understanding of ES demand, indicators to measure demand and the approaches used to quantify and map demand. We identified four distinct "*demand types*", which relate to different ecosystem service categories. These demand types include demand expressed in terms of (1) risk reduction, (2) preferences and values, (3) direct use or (4) consumption of goods and services. Each of the demand types was linked to specific methods applied in the reviewed literature. We found that operationalization of ES demand in policy, planning and management requires a more consistent understanding and definition of ES demand, its drivers and its temporal dynamics. Furthermore, the impact of demands for multiple ecosystem services on land use change needs to be investigated. This will allow for the consideration of temporal and cross-level interactions between supply and demand of ecosystem services and its impacts in land use change modelling.

Contents

1. Introduction 160
2. Review methods 160
3. Definitions and conceptualizations of ES demand 161
   3.1. Definitions 161
      3.1.1. ES demand 161
      3.1.2. ES flow and supply 162
   3.2. Operationalization of ES demand 162
      3.2.1. Risk reduction 163
      3.2.2. Preferences and values 163
      3.2.3. Demand as direct use 164
      3.2.4. Demand as consumption 165
      3.2.5. Framing demand 165
4. Review of ES quantification and mapping methods 165
   4.1. Empirical methods 165
   4.2. Participatory approaches 165
   4.3. Expert based approaches 166
   4.4. Process based models 166
   4.5. Monetary valuation 166
   4.6. Linking methods with demand types 167

* Corresponding author. Tel.: +31 020 59 65745.
E-mail address: sarah.wolff@vu.nl (S. Wolff).

http://dx.doi.org/10.1016/j.ecolind.2015.03.016
1470-160X/

5. Discussion 167
5.1. Review of methods and indicators 167
5.2. Operationalization of ES demand 167
6. Recommendations 169
6.1. Improve the understanding of demand for ecosystem services 169
6.2. Improve mapping by building on understanding of demand types 169
6.3. Improve the understanding of spatio-temporal dynamics of demand 169
6.4. Assess ES demand as a driver of land use change 169
Acknowledgements 169
References 169

1. Introduction

Land use and management decisions are influenced by human demand for goods and services supplied by the land. Many land use models represent land use change solely in response to changes in the agricultural economy or housing market (Brown et al., 2013). However, societal changes have caused new land use change trajectories, such as increasing areas of land managed to conserve nature or provide recreational space. Changing demand and preferences for goods and services supplied by the land (ecosystem services, (ES)) result from factors such as increasing wealth, evidence of negative externalities of existing land management, urbanization, lifestyle changes and pressure on natural resources (Zasada, 2011). Especially for cultural services, such as leisure, protection of cultural heritage, and products which reflect the cultural identity of the region novel societal demands have emerged (Willemen et al., 2010; Plieninger et al., 2013a). On the local scale, multi-functional agricultural landscapes and peri-urban areas provide clear evidence of land use changes driven by demands for multiple ES. In these landscapes, traditional, production-driven forms of land uses are replaced by a mix of land uses meeting demands such as aesthetical and recreational values, nature conservation or safeguarding of hydrological functions (Willemen et al., 2010; Holmes, 2006; Zasada, 2011; Mander et al., 2007).

The interest in ES is driving a "*revaluation*" of land (Holmes, 2008; Sikor et al., 2013). Forests, initially valued for their provision of wood, are now increasingly valued for their function as global carbon sinks and regulators of water resources. At the same time, land governance structures have shifted from territorial arrangements to those centred on particular flows of ES. New demand-driven (international) instruments like subsidies for landscape maintenance, payments for ES or certification systems provide incentives to adapt land systems to the demand of (distant) consumers of ES (Lambin et al., 2014; Sikor et al., 2013).

In spite of the increasing interest in the demand for a wide range of ES, most ES assessments have focused on studying the stocks and spatial distribution of ES supply (Bagstad et al., 2014; Burkhard et al., 2013; Maes et al., 2012; Syrbe and Walz, 2012). Only recently, the ES community has started to map the spatial variations in ES demand (Burkhard et al., 2012; Mcdonald, 2009; Schulp et al., 2014b; Syrbe and Walz, 2012). Inclusion of ES demand in ecosystem assessment is assumed to increase policy relevance and practical application of the ES concept in operational management (Honey-Rosés et al., 2013; Orenstein and Groner, 2014).

However, despite increased efforts to map ES demand, the comprehension of the concept diverges strongly. In order to include ES demand in environmental assessments and scenario development, there is a need to gain improved understanding of the characteristics and variability of ES demand, its driving forces, and relations to human behaviour and social and environmental change (Hulme, 2011).

This paper reviews the current conceptual understanding of ES demand and provides an overview of the available approaches to map demand for different ES. Section 2 describes the methods used for the literature review. Section 3 synthesizes the current conceptual understanding of ES demand. The literature on ES quantification and mapping methods is reviewed and evaluated in terms of their utility to understand, quantify and map demand for ES in Section 4. The discussion and recommendation sections identify knowledge gaps and ways to advance the mapping of ES demand.

2. Review methods

Studies that have mapped demand for ES have been collected by querying the Web of Science database. The journal ecosystem services (not included in Web of Science) was queried separately due to its specific relevance to the topic area. The search was conducted between June and July 2014 and the applied keyword combinations are documented in Table S1 of the Supplementary Material. The literature resulting from the keyword search was narrowed down by reading the abstracts and screening the texts. Since there are a variety of perspectives and ambiguity of what is understood and measured as demand, we limited ourselves to studies that explicitly stated to have mapped "*demand*" for services and that have provided an actual mapping of the spatial distribution of demand for ES. As values, preferences and benefits are often used as proxies for demand, we included studies using these terms as well. Studies which have valued and quantified ES benefits in monetary terms were only included if they contained an explicit spatial quantification and mapping of ES demand. For the classification of ecosystem service types the Millennium Ecosystem Assessment was used (MEA, 2003).

Supplementary Table S1 related to this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ecolind.2015.03.016.

We identified 31 studies that mapped ES demand, published in 2012 (6), 2013 (12) and 2014 (13). The majority of studies focusses on continental Europe or European countries (Fig. 1). Only studies addressing the demand for cultural ecosystem services are more geographically spread. Most demand studies for cultural services focus on recreation and eco-tourism. Only two studies focus on demand for more intangible services, such as identity, spiritual values, and heritage (Nahuelhual et al., 2014; Plieninger et al., 2013b). Studies that have mapped demand for provisioning services focus on food, energy and water (e.g. Burkhard et al., 2012; Kroll et al., 2012; Boithias et al., 2014). Demand for regulating services has been mapped for flood regulation, pollination, erosion control, and carbon sequestration. Flood regulation is currently receiving the most attention among ES demand studies. An overview of the reviewed studies, identified demand types, methods, as well as their spatial distribution and scale of analysis can be found in Table S2 of the Supplementary Material.

Supplementary Table S2 related to this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ecolind.2015.03.016.