Ecological Indicators 95 (2018) 417–426

Contents lists available at ScienceDirect

Ecological Indicators

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

Discussion

Key criteria for developing ecosystem service indicators to inform decision making

Alexander P.E. van Oudenhoven[a,*], Matthias Schröter[b,c], Evangelia G. Drakou[d], Ilse R. Geijzendorffer[e], Sander Jacobs[f,g], Peter M. van Bodegom[a], Laurent Chazee[e], Bálint Czúcz[h,i], Karsten Grunewald[j], Ana I. Lillebø[k], Laura Mononen[l,m], António J.A. Nogueira[k], Manuel Pacheco-Romero[n], Christian Perennou[e], Roy P. Remme[o], Silvia Rova[p], Ralf-Uwe Syrbe[j], Jamie A. Tratalos[q], María Vallejos[r], Christian Albert[s]

[a] Institute of Environmental Sciences CML, Leiden University, Einsteinweg 2, 2333 CC Leiden, The Netherlands
[b] UFZ – Helmholtz Centre for Environmental Research, Department of Ecosystem Services, Department of Computational Landscape Ecology, Permoserstr. 15, 04318 Leipzig, Germany
[c] German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, Deutscher Platz 5e, 04103 Leipzig, Germany
[d] Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente, P.O. Box 6, 7500 AA Enschede, The Netherlands
[e] Tour du Valat, Research Institute for the Conservation of Mediterranean Wetlands, Le Sambuc, 13200 Arles, France
[f] Research Institute of Nature and Forest INBO, Havenlaan 88 bus 73, 1000 Brussels, Belgium
[g] Belgian Biodiversity Platform BBPF, Av. Louise 231, 1050 Brussels, Belgium
[h] European Topic Centre on Biological Diversity, Muséum national d'Histoire naturelle, 57 rue Cuvier, FR-75231 Paris, Paris Cedex 05, France
[i] MTA Centre for Ecological Research, Institute of Ecology and Botany, Klebelsberg K. u. 3, H-8237 Tihany, Hungary
[j] Leibniz Institute of Ecological Urban and Regional Development, Weberplatz 1, 01217 Dresden, Germany
[k] Department of Biology & CESAM – Centre for Environmental and Marine Studies, University of Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal
[l] Finnish Environment Institute, Natural Environment Centre, P.O. Box 111, 80101 Joensuu, Finland
[m] University of Eastern Finland, Department of Geographical and Historical Studies, P.O. Box 111, 80101 Joensuu, Finland
[n] Andalusian Center for the Assessment and Monitoring of Global Change (CAESCG), Department of Biology and Geology, University of Almería, Carretera Sacramento, s/n, 04120 La Cañada de San Urbano, Almería, Spain
[o] National Institute of Public Health and the Environment (RIVM), Postbus 1, 3720 BA Bilthoven, The Netherlands
[p] Environmental Sciences, Informatics and Statistics Dept., University Ca' Foscari of Venice, Via Torino 155, 30170 Venice, Italy
[q] UCD Centre for Veterinary Epidemiology and Risk Analysis, UCD School of Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland
[r] Regional Analysis and Remote Sensing Laboratory (LART), Faculty of Agronomy, University of Buenos Aires, Av. San Martín, 4453 C1417DSE, Buenos Aires, Argentina
[s] Leibniz Universität Hannover, Institute of Environmental Planning, Herrenhaeuser Str. 2, 30419 Hannover, Germany

ARTICLE INFO

Keywords:
Science-policy interface
CSL
Credibility
Salience
Legitimacy
Feasibility

ABSTRACT

Decision makers are increasingly interested in information from ecosystem services (ES) assessments. Scientists have for long recognised the importance of selecting appropriate indicators. Yet, while the amount and variety of indicators developed by scientists seems to increase continuously, the extent to which the indicators truly inform decision makers is often unknown and questioned. In this viewpoint paper, we reflect and provide guidance on how to develop appropriate ES indicators for informing decision making, building on scientific literature and practical experience collected from researchers involved in seven case studies. We synthesized 16 criteria for ES indicator selection and organized them according to the widely used categories of credibility, salience, legitimacy (CSL). We propose to consider additional criteria related to feasibility (F), as CSL criteria alone often seem to produce indicators which are unachievable in practice. Considering CSLF together requires a combination of scientific knowledge, communication skills, policy and governance insights and on-field experience. In conclusion, we present a checklist to evaluate CSLF of your ES indicators. This checklist helps to detect and mitigate critical shortcomings in an early phase of the development process, and aids the development of effective indicators to inform actual policy decisions.

* Corresponding author.
E-mail addresses: a.p.e.van.oudenhoven@cml.leidenuniv.nl, alexander.vanoudenhoven@gmail.com (A.P.E. van Oudenhoven).

https://doi.org/10.1016/j.ecolind.2018.06.020
Received 16 January 2018; Received in revised form 6 June 2018; Accepted 7 June 2018

1. Introduction

Research on ecosystem services (ES), the contribution of ecosystems to human wellbeing (TEEB, 2010), is often claimed to inform policy and decisions in various contexts such as biodiversity conservation, natural resource management, and spatial planning (Daily et al., 2009; Laurans and Mermet, 2014; Martinez-Harms et al., 2015). Decision makers are increasingly interested in ES assessments (Maes et al., 2016; Pascual et al., 2017). Indicators to track and communicate trends in the quantity and quality of ES form a crucial foundation for these assessments (Ash et al., 2010; Layke et al., 2012). From the onset of ES assessments, the importance of developing appropriate indicators has been recognised, and many ES indicators and corresponding datasets have been developed, applied, tested and reviewed. This has been done for different purposes and in different contexts, be it methodological (van Oudenhoven et al., 2012; Böhnke-Henrichs et al., 2013) or policy-oriented (Albert et al., 2016b; Maes et al., 2016; Geijzendorffer et al., 2017).

At the same time, there is an increasing uneasiness in the scientific and decision-making community as to whether the proposed ES indicators truly inform decision making (Laurans and Mermet 2014). Apparently, many ES indicators are not considered appropriate for a specific purpose and are simply not used for decision making. Discussion on the suitability of indicators has remained mainly academic and the main criteria discussed have been their scientific credibility or precision (e.g. Layke et al., 2012; van Oudenhoven et al., 2012; Geijzendorffer et al., 2015). Discussions on the usability of ES research outputs by decision makers, and what this application depends on, have only recently emerged in the scientific literature (Caliman et al., 2010; Martinez-Harms et al., 2015; Wright et al., 2017). For instance, Palomo et al. (2018) identified the lack of user-centred design of ES assessments to be one of the major gaps in the usability of ES. Similarly, Drakou et al. (2017) identified lack of engagement of specific stakeholder groups and difficulty of some ES indicators to account for complexity, to be among the key issues that hinder the usability of ES information by decision makers. In the cases where user-centred design was applied, ES assessments were linked to the development of specific decision-making web platforms or tools for a specific group of stakeholders (e.g. Klein et al., 2016; Wissen Hayek et al., 2016).

Cash et al. (2003) published a seminal and widely cited paper on the conditions under which information on sustainability, science and technology is likely to be used by relevant stakeholders. According to them, the probability of scientific information uptake increases if researchers take demands of users for that information as a starting point; i.e. the question what information should be produced and what it should contain to instigate policy action. More specifically, Cash et al. (2003) argue that scientific information is likely to be effective in influencing decision making if the relevant stakeholders perceive the presented information to be not only credible, but also salient and legitimate. Credibility refers to whether the evidence and arguments are perceived as scientifically adequate. Salience indicates whether the assessment that resulted in the information is relevant to the needs of decision makers. Legitimacy relates to the question whether the generation of information has been unbiased, and has been respectful of the decision makers' diverse values. The usefulness of considering credibility, salience and legitimacy (CSL from here on) has been recognised for the design of environmental and ecosystem assessments (Ash et al., 2010; Posner et al., 2016; Wright et al., 2017). However, this does not automatically imply that such criteria are applied. To the best of our knowledge, studies have yet to apply CSL criteria in the process of developing ES indicators in existing ES assessments.

Considering the above, this viewpoint paper evaluates relevant literature and personal experiences of researchers involved in seven case studies under the growing 'ES indicator umbrella', in order to achieve more effective permeation of ES information into decision making. The paper aims to provide guidance on how to develop (i.e. to generate and select) more appropriate ES indicators for informing decision making. To achieve this, we identify criteria for ES indicator development from the scientific literature and test their alignment with the CSL categories put forward by Cash et al. (2003). In addition, we reflect on the ES indicator development processes embedded in seven (inter)national and regional ES assessment projects aiming to inform decision making, thereby taking the perspective of scientists at the science-policy interface. We evaluate which criteria were used and whether these can be placed in the CSL or other categories. We reflect on how the criteria were tested in different case studies, as well as on the lessons learned. Finally, we propose a checklist to consider when developing ES indicators.

2. Synthesising criteria for ES indicator development

We synthesized criteria for ES indicator selection and generation, and organized them according to the broad categories of CSL. We explored relevant literature and selected case studies (i) to identify criteria for 'appropriate' ES indicators, (ii) to cluster the proposed criteria into distinctive categories, and (iii) to assign and map these criteria to the CSL categories proposed by Cash et al. (2003).

We explored the relevant literature in Web of Science on ES indicators based on the terms "ecosystem service" AND "indicator". Using the 'sort by relevance' option within Web of Science, we explored the ten most relevant research papers, the ten most relevant review papers, and the ten most highly cited papers overall. Out of these three categories, we only considered papers that discuss, propose or use criteria for ES indicator selection and generation in the context of informing decision making. Furthermore, adopting a 'snowballing' approach, several citing and cited studies were also considered to identify criteria for ES indicator development for decision making. We complemented the obtained paper selection with a consultation of technical reports by Brown et al. (2014) and Maes et al. (2014), which explicitly deal with selecting and quantifying indicators to support decision making in the context of ecosystem assessments. An overview of the 22 key sources considered can be found in Appendix 1.

In addition to the literature search, we collected information on first-hand experiences by researchers involved in ES assessments at the science-policy interface. This was done through a targeted dialogue with researchers, during a workshop facilitated by the working group of the Ecosystem Services Partnership on ES Indicators (https://www.es-partnership.org/community/workings-groups/thematic-working-groups/twg-3-es-indicators/). The workshop was set up during the European Ecosystem Services Conference in Antwerp (19–23 September 2016; https://www.esconference2016.eu/86157/part_program#.Wzx7C-6WS9J) and included participants from a wide range of European countries who used ES indicators in different decision-making contexts. For this paper, we selected case studies with a clear link to decision making.

For each case study we extracted information on its purpose, the associated project, the policy question assessed and, if applicable, the mandate (Table 1). In addition, the contributing researchers provided information on the applied criteria for appropriate indicators as well as the approach followed to assess the criteria. Contributing researchers were asked to name criteria that they perceived to correspond with CSL, but were also requested to list additional criteria. Appendix 2 provides an overview of all questions asked to contributing researchers.

The criteria emerging from the literature and the cases were assigned to the CSL categories. The criteria were aligned to each category and we assessed potential synergies or conflicts between the different categories. Finally, with a robust list of criteria generated (Table 2) and after consultation with participating researchers, we reflected on the relevance of the different clusters of criteria for indicator development in the different cases.