On the importance of a broad stakeholder network for developing a credible, salient and legitimate tiered approach for assessing ecosystem services

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Academic editor: Fernando Santos

Abstract

As the concept of ecosystem services is being operationalised and implemented in policies, a better guidance on the selection of suitable methods for ecosystem services mapping and assessment is needed to allow more sound, transparent and comparable processes. A vast range of assessments focusing on different sets of ecosystem services at various scales is existing and the applied methods cover different disciplines from ecology to economy and social sciences. This complicates the assessment of single or bundles of ecosystem services across spatio-temporal scales and requires a broad expertise. A tiered approach for ecosystem services assessment allows selecting the appropriate application of a certain method for tackling a specific question at a given scale. In this publication, we illustrate how the EU H2020 project ESMERALDA supported the development of such a tiered approach for assessing ecosystem services. The iterative exchanges between experienced researchers and practitioners in mapping and assessing ecosystem services in various contexts allowed the co-production of an approach to guide the choice of methods. Ultimately, the proposed tiered approach will not only support communication of the ecosystem services concept, but will also reduce the tendency for selecting an unsuitable approach for solving complex problems linked to ecosystem services-based resource management.

Keywords

Operationalization, mapping, iterative process, transdisciplinary process

Background: The need for structuring ecosystem services mapping and assessment

Haltering the loss of life-supporting services provided by nature is one of the most important challenges currently facing humanity. Despite the recognition of the need for action, decision-making is facing important uncertainties related to different aspects of global change (see Polasky et al. 2011). Predicting impacts of decisions on nature and the services it provides for people at a specific place and time is challenging because of the mutual interlinkages and dependencies in complex dynamic human-environment systems. The concept of ecosystem services (ES) which has become increasingly popular, especially after the publication of the Millennium Ecosystem Assessment (2005), allows integrating different environmental characteristics including cultural aspects into decision-making (Maes et al. 2012). For a review on the rise of the concept, we refer to Chaudhary et al. (2015) and Costanza et al. (2017). While the potential of the concept has meanwhile been well recognised, putting it into action, i.e. delivering information useful to decision-makers, remains challenging (Carpenter et al. 2009, Daily et al. 2009, Groot et al. 2010). In the past years, efforts have been made to overcome limitations and to bridge gaps related to methodological aspects such as mapping of ES (see Kareiva et al. 2011, Malinga et al. 2015,Burkhard and Maes 2017), valuation of ES (see Sukhdev et al. 2014, Jacobs et al. 2018) or the integration of ES in decision-support tools (see Bagstad et al. 2013, Grêt-Regamey et al. 2017a). Various recent research projects and international programmes (see Costanza et al. 2017 for a list of programmes and institutions) have supported these efforts and generated tools and decision-support platforms (for a review, see Grêt-Regamey et al. 2017a).

Depending on the purpose of the decision-making process or the question behind an assessment, various ES information is required at different locations in space and in various time-frames. The information required usually varies regarding needs of precision, resolution and accuracy and the selection of ES to be considered depends on the issue at stake. This makes the selection of methods and data for the assessments difficult. Recently, decision-trees for the selection of biophysical, economic and socio-cultural methods were developed in the frame of the EU project OpenNESS*[1] (Harrison et al. 2018). The OpenNESS decision-trees are based on the experience of 27 case studies. The authors list reasons for method selection and define the key features of the methods. The decision-trees are clearly structured and consider relevant aspects of ES mapping and assessment. The difficulty with identifying a single method is that the method as such can usually be applied at various levels of complexity. For example, process-based models can be very complex consisting of various parameters and interlinkages, but they can also be rather simple and only consider few parameters. Lookup tables, on the other hand, are a comparably simple method but can consider many variables, which allow them to illustrate complex situations (Burkhard et al. 2012).

Tiered approaches

Standardised reporting is known, for example, in the frame of climate reporting for the Intergovernmental Panel on Climate Change IPCC: Greenhouse gas emissions have to be reported in a form which:

1. allows regular updating,
2. is applicable in places with simple infrastructure and sparse available information and
3. enables the integration of a vast variety of data available in better studied regions.

The IPCC's approach gives clear guidance on how to assess the greenhouse gas emissions at various spatial and time-scales. This facilitates the comparison across countries but also across different reporting periods. Depending on the question and the purpose of the reporting and the available data sets, a specific tier level is selected. How can this be transferred to the ES concept? The InVEST tool*[2], for example, provides models with two tier levels, one for readily available data and a more complex one (Kareiva et al. 2011). While, for the national reports on greenhouse gas emissions, the purpose of the assessment is clear, ES mapping and assessment are usually intended for various applications, i.e. different purposes and questions from policy, science, business and society (see Maes et al. this issue).

The proposed tiered approach for ecosystem services mapping and assessment

Under the EU H2020 coordination and supporting action ESMERALDA*[3] (Enhancing ecoSysteM sERvices mApping for poLicy and Decision mAking), a tiered approach was developed based on earlier suggestions (Grêt-Regamey et al. 2015) and is presented in the open access book "Mapping Ecosystem Services"*[4] (Grêt-Regamey et al. 2017b in Burkhard and Maes 2017). A decision-tree helps the user to identify the relevant tier level and indicates example methods that are often applied at this level. The goal is to provide guidance for selecting ES assessment and mapping methods. In order to generate a consensus on a tiered approach amongst researchers and practitioners, an iterative transdisciplinary process was started. A sequence of four workshops with members of ESMERALDA (whereof 44% came from Universities, 16% from other academia, 28% from state and other superior organisations and 12% from small-to medium scale enterprises originating from all 28 EU member states and Switzerland, Norway and Israel), intertwined with two additional workshops with stakeholders (national authorities responsible for mapping ecosystem services under the EU Biodiversity Strategy's Target 2 Action 5*[5], allowed taking into account diverse actors' views and discussing trade-offs associated with each possible approach (ESMERALDA 2015). In Fig. 1, the sequence of the workshops is presented in an overview.

In a first step, a survey amongst EU member state representatives identified key stakeholders and revealed gaps and requirements for ES mapping and assessments (Kopperoinen et al. 2016). While it was clear from the beginning that we would develop a three-step tiered approach ranging from rather simple (tier 1) to more complex (tier 3) approaches, we soon realised that the definition of the tiers remained challenging. The tiers were not clearly and exclusively linked to one specific aspect such as the scale (global to local) or the type of data (primary vs. secondary). Furthermore, it became obvious that assigning a unique method to a specific tier level would require a very narrow definition of the method as most methods can be applied at various levels of complexity.

These issues became clearer during the second workshop in Nottingham in 2016. A task-force was then established to further elaborate on the tiered approach, which was presented at a second workshop in Prague (2016) and further described in the “Mapping ecosystem services” Open access book (Grêt-Regamey et al. 2017b). Around these two workshops, two other stakeholder-orientated workshops were held in Riga (2015) and Plovdiv (2017), where the tiered approach and various ES mapping and assessment case studies from across Europe were presented and discussed with the decision-makers and practitioners from EU member states and the European Commission. This process not only aimed at exchanging knowledge but at generating a new approach that exceeded the disciplinary origins of the participants. The first result of the co-production was the definition of an entry point to ES assessments, which focused on the purpose of the assessment rather than the available method, scale or the required data. In a follow-up step, we discussed how the tiered approach could be linked to a database of case studies during a workshop in Amsterdam in 2017. Here, we realised that asking the partners to describe the tier level of their case study resulted in very different statements, as the understanding of the tier categories was not entirely clear.

In ESMERALDA, a comprehensive database of various ES mapping and assessment methods was developed (Santos-Martin et al. this issue). The project members were asked to enter methods they used in their case studies, but also to consider non-scientific studies. Several categories had to be described systematically for each method, such as the spatial scale, the type of method, the valuation domain (biophysical, social-cultural, economic) and the ecosystem type and ecosystem service addressed. For the tier level, the answers were not very consistent with the provided definition and often left blank. This led us to explicitly include categories related to the purpose of the case study rather than the tier level itself (Potschin et al. 2017): “Is it a **scoping study** (e.g. what sort of ecosystem services are provided in a region and what are the correlations between them; what is the role of forest to provide flood and erosion control)? Is it a study looking at possible **management options** (e.g. how can we ensure in a region the delivery of ecosystem services while protecting vulnerable nature; often trade-off questions)? Is the study describing the **implementation of a plan** (e.g. the study concludes that a land conversion project or a restoration will decrease or increase ecosystem services with 10%)?" The concept of the tiered approach is illustrated in Fig. 2 for the service pollination. The pollination potential decreases with increasing distance related to the common range of pollinators. For a rough overview (tier 1), the distance between the areas for agricultural production and extensively

managed areas is estimated. The pollination service is highest near these land use types. For a more detailed analysis, the distance to different crops is considered together with suitable habitat types for pollinators (tier 2). This also allows for the consideration of the yield of specific crops. To understand the effect of a specific change in land use or land management for example (tier 3), the analysis considers different management practices and related characteristics such as pesticide use or the time the crops are harvested together with the habitat type and quality for several pollinator species.

A final decision about the tiered approach was the goal of a breakout session at the workshop in Madrid in 2017. In Madrid, we presented and discussed a first validation step, in which a small subsample of the ESMERALDA methods database was used to evaluate how the reported case studies could be linked to the tier levels. The discussion during the workshop revealed that the concept of the tiered approach had already been applied by several partners intuitively and seemed to be clear in its definition and application. In this workshop, the tiered approach was described as a useful tool for communication, particularly in stakeholder processes and to communicate the quality and origin of an ES map (Santos Martín et al. 2017). The stakeholder workshop in Plovdiv in 2017 had 83 registered participants from 30 European countries, which indicates that the ESMERALDA project has successfully established a network consisting of members from the European Commission, the MAES (Mapping and Assessment of Ecosystems and their Services*[6]) working group, the ESMERALDA Science-Policy-Society Advisory Board SPSAB and the ESMERALDA project partners. During the discussions, it was agreed that more and specific guidance is needed in “what can and cannot be achieved by different methods” (Sieber et al. 2017). This can be supported by the developed tiered approach suggesting methods for a specific purpose and thus indicating what can be achieved or where other methods would be more suitable.

Outlook

To better link the identified tier level to specific ES mapping and assessment methods and case studies, we will evaluate, in a next step, over 500 studies reported under the ESMERALDA project. This covers not only scientific literature but also reports and non-English literature (often referred to as “grey literature”). By doing so, we combine the selection of methods with other aspects such as the spatial scale, the type of ecosystem service addressed, the type of input data used in order to deliver a bundle of information together with the method selection. Finally, the identification of best practices will also allow making recommendations on the selection of ES mapping and assessment methods clearer and the application more useful, efficient and user-specific.

Acknowledgements

The ESMERALDA project receives funding from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement No. 642007.

Funding program

European Union's Horizon 2020 research and innovation programme, Grant Agreement No. 642007

Conflicts of interest

References

- Bagstad K, Semmens D, Waage S, Winthrop R (2013) A comparative assessment of decision-support tools for ecosystem services quantification and valuation. Ecosystem Services 5: 27-39. https://doi.org/10.1016/j.ecoser.2013.07.004
- Burkhard B, Kroll F, Müller F, Nedkov S (2012) Mapping ecosystem service supply, demand and budgets. Ecological Indicators 21: 17-29. https://doi.org/10.1016/j.ecolind.2011.06.019
- Burkhard B, Maes J (Eds) (2017) Mapping Ecosystem Services. Pensoft Publishers, Sofia. [ISBN 978-954-642-852-3] https://doi.org/10.3897/ab.e12837
- Carpenter S, Mooney H, Agard J, Capistrano D, DeFries R, Díaz S (2009) Science for managing ecosystem services: Beyond the Millennium Ecosystem. Proceedings of the National Academy of Sciences 106 (5): 1305-1312. https://doi.org/10.1073/pnas.0808772106
- Chaudhary S, McGregor A, Houston D, Chettri N (2015) The evolution of ecosystem services: A time series and discourse-centered analysis. Environmental Science & Policy 54: 25-34. https://doi.org/10.1016/j.envsci.2015.04.025
- Costanza R, Groot Rd, Braat L, Kubiszewski I, Fioramonti L, Sutton P, Farber S, Grasso M (2017) Twenty years of ecosystem services: How far have we come and how far do we still need to go? Ecosystem Services 28: 1-16. https://doi.org/10.1016/j.ecoser.2017.09.008
- Daily G, Polasky S, Goldstein J, Kareiva P, Mooney H, Pejchar L (2009) Ecosystem services in decision making: time to deliver. Frontiers in Ecology and the Environment 7 (1): 21-28. https://doi.org/10.1890/080025
- ESMERALDA (2015) Description of Action DoA. EU Horizon 2020 ESMERALDA Project Grant Agreement No. 642007
- Grêt-Regamey A, Weibel B, Kienast F, Rabe S, Zulian G (2015) A tiered approach for mapping ecosystem services. Ecosystem Services 13: 16-27. https://doi.org/10.1016/j.ecoser.2014.10.008
- Grêt-Regamey A, Sirén E, Brunner SH, Weibel B (2017a) Review of decision support tools to operationalize the ecosystem services concept. Ecosystem Services 26: 306-315. https://doi.org/10.1016/j.ecoser.2016.10.012
- Grêt-Regamey A, Weibel B, Rabe S, Burkhard B (2017b) A tiered approach for ecosystem services mapping. In: Maes J, Burkhard B (Eds) Mapping ecosystem services. Pensoft Publishers, Sofia. [ISBN 978-954-642-852-3]. https://doi.org/10.3897/ab.e12837

- Groot RS, Alkemade R, Braat L, Hein L, Willemen L (2010) Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological Complexity 7 (3): 260-272. https://doi.org/10.1016/j.ecocom.2009.10.006
- Harrison P, Dunford R, Barton D, Kelemen E, Martín-López B, Norton L, Termansen M, Saarikoski H, Hendriks K, Gómez-Baggethun E, Czúcz B, García-Llorente M, Howard D, Jacobs S, Karlsen M, Kopperoinen L, Madsen A, Rusch G, Eupen Mv, Verweij P, Smith R, Tuomasjukka D, Zulian G (2018) Selecting methods for ecosystem service assessment: A decision tree approach. Ecosystem Services 29: 481-498. https://doi.org/10.1016/j.ecoser.2017.09.016
- Jacobs S, Martín-López B, Barton D, Dunford R, Harrison P, Kelemen E, Saarikoski H, Termansen M, García-Llorente M, Gómez-Baggethun E, Kopperoinen L, Luque S, Palomo I, Priess J, Rusch G, Tenerelli P, Turkelboom F, Demeyer R, Hauck J, Keune H, Smith R (2018) The means determine the end – Pursuing integrated valuation in practice. Ecosystem Services 29: 515-528. https://doi.org/10.1016/j.ecoser.2017.07.011
- Kareiva P, Tallis H, Ricketts T, Daily G, Polasky S (2011) Natural capital. Theory & practice of mapping ecosystem services. Oxford Univ. Press (Oxford biology, Oxford. URL: http://www.loc.gov/catdir/enhancements/fy1112/2010942945-b.html [ISBN 9780199588992]
- Kopperoinen L, Maes J, Streberová E, Pártl A, Pitkänen K, Virag-Prokai R (2016) Ecosystem service mapping and assessment gaps in EU member states and recommendations to overcome them; Deliverable 2.2. EU Horizon 2020 ESMERALDA Project, Grant agreement No. 642007
- Maes J, Egoh B, Willemen L, Liquete C, Vihervaara P, Schägner JP, Grizzetti B, Drakou E, Notte AL, Zulian G, Bouraoui F, Paracchini ML, Braat L, Bidoglio G (2012) Mapping ecosystem services for policy support and decision making in the European Union. Ecosystem Services 1 (1): 31-39. https://doi.org/10.1016/j.ecoser.2012.06.004
- Malinga R, Gordon L, Jewitt G, Lindborg R (2015) Mapping ecosystem services across scales and continents – A review. Ecosystem Services 13: 57-63. https://doi.org/10.1016/j.ecoser.2015.01.006
- Millennium Ecosystem Assessment (2005) Ecosystems and human well-being. Synthesis. Island Press, Washington DC. [ISBN 1-59726-040-1]
- Polasky S, Carpenter S, Folke C, Keeler B (2011) Decision-making under great uncertainty: environmental management in an era of global change. Trends in Ecology & Evolution 26 (8): 398-404. https://doi.org/10.1016/j.tree.2011.04.007
- Potschin M, Santos Martin F, Arany I, Brander L, Nedkov S, Vihervaara P, Viinikka A (Eds) (2017) ESMERALDA Method Database guidelines. EU Horizon 2020 ESMERALDA Project, Grant agreement No. 642007
- Santos Martín F, Carlos M, Pitkänen K, Viinikka A, Adem Esmail B, Burkhard B, Geneletti D, Kopperoinen L, Nedkov S, Potschin M (2017) ESMERALDA Workshop V on testing the methods across biomes and regions. EU Horizon 2020 ESMERALDA Project, Grant Agreement No. 642007
- Sieber I, Bicking S, Adem Esmail B, Arnell A, BROWN C, Santos-Martín F, Nedkov S, Stoev P, Geneletti D, Maes J, Kopperoinen L, Potschin-Young M, Burkhard B (2017) ESMERALDA Mid-term project Meeting and Workshop VI on Flexible methods for mapping and assessing ecosystem services. EU Horizon 2020 ESMERALDA Project, Grant Agreement No. 642007

- Sukhdev P, Wittmer H, Miller D (2014) The Economics of Ecosystems and Biodiversity (TEEB): Challenges and Responses. In: Helm D, Hepburn C (Eds) Nature in the Balance: The Economics of Biodiversity. Oxford University Press, Oxford. [ISBN 9780199676880]. https://doi.org/10.1093/acprof:oso/9780199676880.001.0001

Endnotes

*1 http://www.openness-project.eu/
*2 https://www.naturalcapitalproject.org/invest/
*3 http://www.esmeralda-project.eu/
*4 http://ab.pensoft.net/articles.php?id=12837
*5 http://ec.europa.eu/environment/nature/biodiversity/strategy/target2/index_en.htm
*6 http://biodiversity.europa.eu/maes

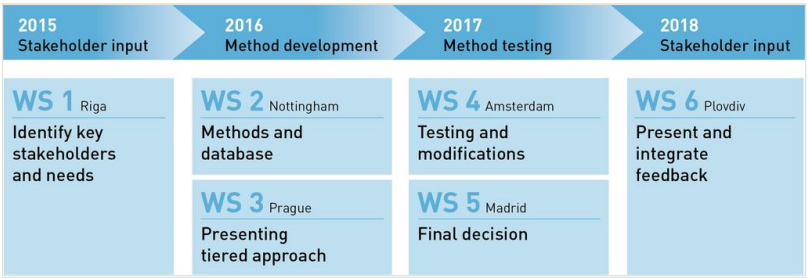

Figure 1.

Overview of ESMERALDA workshops (WS) relevant for the development of the tiered approach.

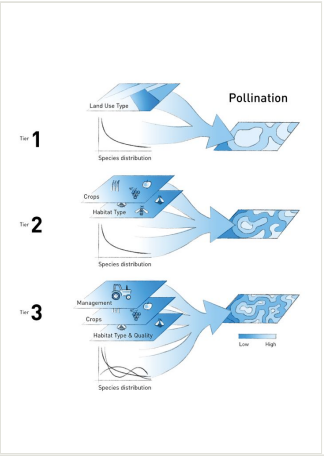

Figure 2.

Estimating the pollination service at three different tier levels.