A tiered approach for ecosystem services mapping

Book Chapter

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5.6.1. A tiered approach for ecosystem services mapping

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Introduction: The need for a tiered approach in ES mapping

Understanding strengths and weaknesses of the different ecosystem services (ES) mapping methods is crucial for understanding what information can be derived from a map and how applicable it eventually will be. Particularly, information about reliability, accuracy and precision of ES maps is important for users to determine their suitability in a specific context (see Chapters 3.7 and 6.3). ES mapping approaches can broadly be classified into five categories:

1. A simple and widely used approach directly links ES to geographic information, mostly land cover data and is often referred to as the "lookup table" approach. The land cover data are used as proxies for the supply of (or demand for) different ES. The ES in the lookup table can be derived from statistics such as crop yield for agricultural production.

2. Approaches, mainly relying on expert knowledge (see Chapter 4.6), include expert estimates of ES values in lookup tables but also other methods such as Delphi surveys.

3. The "causal relationship" approach estimates ES based on well-known relationships between ES and spatial information retrieved from literature or statistics. For example, timber production can be estimated using harvesting statistics for different areas, elevations and forest types provided in a national forest inventory.

4. Approaches that estimate ES extrapolated from primary data such as field surveys linked to spatial information.

5. Quantitative regression and socio-ecological system models that combine field data of ES as well as information from literature linked to spatial data.

To provide guidance in the choice of the appropriate ES mapping method and to enhance comparability between different ES assessments, tiered approaches can be used. The methods can be categorised into tiers with increasing complexity between the different levels such as, for example, in the TEEB[1] tiered approach. This idea has also been implemented in the InVEST model (see Chapter 4.4) where a simple (tier 1) and more complex (tier 2) approach is suggested.

Usually the tier 1 approach relies on widely available data and the tier 2 approach includes more specific information for the case study area. Another well-established example is the IPCC tiered approach which structures and facilitates the reporting on climate change at

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[1] TEEB stands for The Economics of Ecosystems and Biodiversity; http://www.teebweb.org/

global and national scales. Inventory reports on national greenhouse gas refer to different tiers when describing the methods used and changes in methods from one report to another are related to the tiers defined.

A tiered approach for ecosystem services mapping

Similar to the approaches mentioned above, a tiered approach for ES mapping is proposed in this chapter: it is most useful to define the tiers according to the goal of the mapping exercise (see Chapter 5.4) to make sure the information relevant for the related decision-making process is provided. This supports the efficiency of the mapping process avoiding far too complex approaches where rough estimates would be sufficient.

In a first step, the different components of the analysed human-environment system should be described which include the ecosystems and ES as well as the beneficiaries and institutions involved and their interactions. For example, for microclimate regulation in urban areas, the considered ecosystems are usually green urban areas, the service they provide is microclimate regulation, beneficiaries are residents and institutions are city planning agencies. These system components can be described at different levels of detail, for example, the ecosystem can be described in terms of its condition and structure (see Chapter 3.5), the service provided can be quantified in different units (see Chapter 2.4), the ES demand can be structured according to different beneficiary groups (Chapter 5.1) and different instruments of institutions including NGOs or businesses (see Chapter 7), for example, can be identified. This description of components should make the boundary of the considered system and the

spatial and temporal scale explicit. ES beneficiaries and institutions represent relevant stakeholders who could be considered in the decision-making process.

Once these components have been described, the appropriate tier and associated ES mapping method can be selected. To guide this selection, we present a decision tree in Figure 1. The first question addresses the process-understanding of the human-environment system. If interactions between the system components are relevant and a deeper understanding of processes is needed (e.g. to understand how management of ecosystem components can influence the provision of ES), a tier 3 approach would be required. Otherwise, if the purpose of the map is mainly to provide a rough overview of ES values in a certain area, their abundance, presence and absence, a tier 1 approach can be selected. If information about different ES is required at a certain level of detail but not linked to an explicit management question tackling the human-environment system components and processes, a tier 2 approach may be suitable. However, if the ES map is to be used to explicitly evaluate management measures, again a tier 3 approach should be considered. After the most suitable tier has been identified, the availability of resources for the ES mapping should be evaluated. In case resources are severely limited, a method involving a lower tier can be applied. Yet, efforts should be made to identify the most suitable tier to provide information that is useful for decision-makers.

We associated the five different categories of ES mapping methods (see above) with the different tier levels: while most methods are applicable at all tier levels, they usually have a focus at a certain level as indicated in Figure 1 with the shading. ES quantification and mapping methods are described in more detail in Chapters 4 and 5.
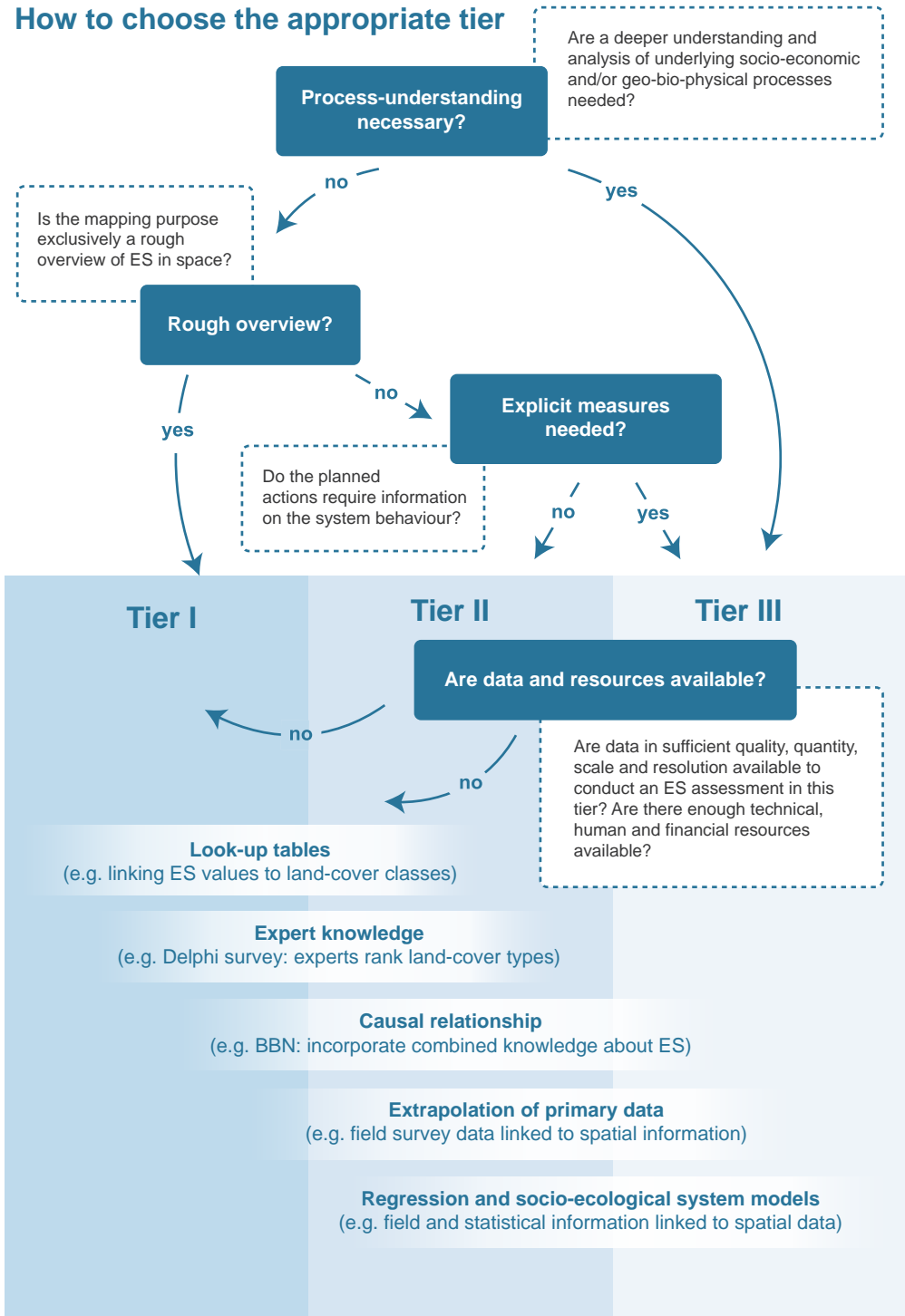
How to choose the appropriate tier

Process-understanding necessary?

Are a deeper understanding and analysis of underlying socio-economic and/or geo-bio-physical processes needed?

no

yes

Is the mapping purpose exclusively a rough overview of ES in space?

Rough overview?

no

yes

Explicit measures needed?

Do the planned actions require information on the system behaviour?

no

yes

Tier I

Tier II

Tier III

Are data and resources available?

no

no

Are data in sufficient quality, quantity, scale and resolution available to conduct an ES assessment in this tier? Are there enough technical, human and financial resources available?

Look-up tables
(e.g. linking ES values to land-cover classes)

Expert knowledge
(e.g. Delphi survey: experts rank land-cover types)

Causal relationship
(e.g. BBN: incorporate combined knowledge about ES)

Extrapolation of primary data
(e.g. field survey data linked to spatial information)

Regression and socio-ecological system models
(e.g. field and statistical information linked to spatial data)

Figure 1. Decision tree guiding the selection of tiers for ES mapping.

Box 1. Illustrating the tiered approach: Microclimate regulation

In this example, we illustrate the tiered approach for mapping microclimate regulation within urban areas with ES mainly provided by green space and important in the context of heat island effects. The components of the human-environment system include green urban spaces as ecosystems, microclimate regulation as provided ES, residents as the main user group and city planning agencies as main institutions. If the purpose is to provide a rough overview, i.e. to compare cities or city districts, no detailed process-understanding is required and a tier 1 approach would be most suitable. Using a lookup table approach, the microclimate regulation can be estimated based on the amount of green space as illustrated in Figure 2. Alternatively, experts could also rank the different land use/land cover (LU/LC) classes according to their suitability for providing microclimate regulation.
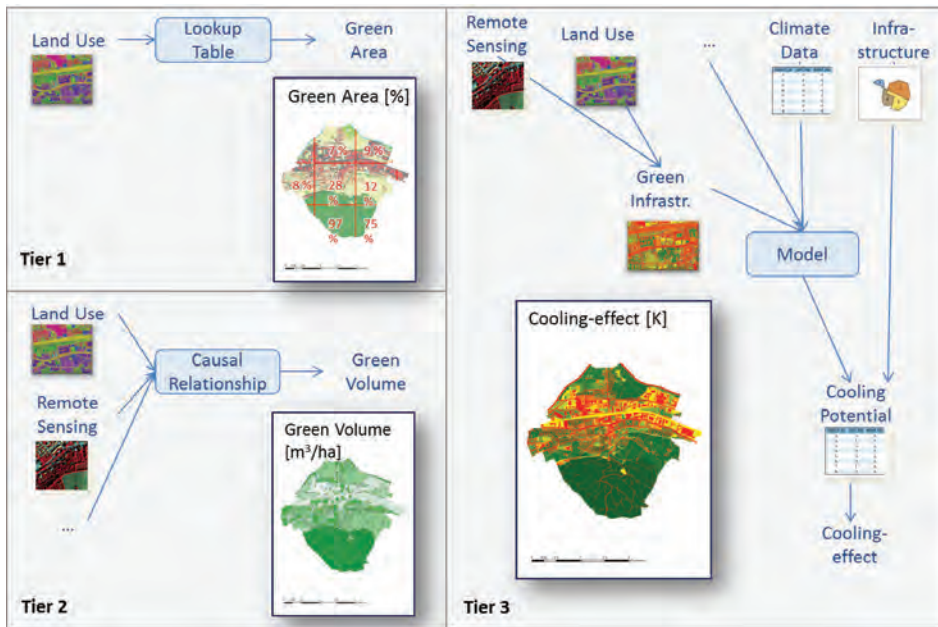
Figure 2. Illustrating the tiered approach for microclimate regulation.

If the map is to be used to analyse microclimate regulation in more detail without providing information for an explicit management measure targeting system components or processes, a tier 2 approach can be applied. Here, we present a causal relationship approach, where the green volume is estimated by combining high resolution remote sensing data with LU/LC information: Green areas are estimated from the remote sensing information based on the normalised-difference-vegetation-index (NDVI), which allows, for example, identifying single trees. Additionally, the remote sensing data provides information about the height of these identified green areas to estimate the volume. As reducing the urban heat islands by increasing microclimate regulation requires an understanding of how certain measures such as changes in the amount and/or structure of green area quantitatively affect the cooling potential, a process-understanding is needed guiding us to a tier 3 approach.

In a tier 3 approach, the cooling effect is estimated based on a model combining ecological information, i.e. the cooling potential of various vegetation types with the given green infrastructure and their green volumes: the volume of green infrastructure can be derived from a detailed land use typology at the cadastral level based on field surveys with classes such as private yards, sport facilities and infrastructural green. Each class of the typology is related to the amount of trees, grasses, shrubs and settlement or infrastructure present. For the categories tree, grass and shrubs, the volume is estimated based on well-known geometric relations and combined with remote sensing information. The potential cooling effect for high, middle and low green infrastructure can then be modelled considering climate information such as precipitation, temperature and solar radiation. Finally, the effect of infrastructure such as roads or buildings on the cooling potential is considered for estimating the resulting cooling effect.

Conclusions

The suggested concept and decision tree provide guidance in the selection of the appropriate tier and associated methods for mapping ES. The presented tiered approach distinguishes the different tiers according to their purpose i.e. the intended use of the ES map. Thus it ensures that ES maps provide information useful to decision-makers in the specific context avoiding either the application of over-complex and resource intensive methods resulting in high costs at a level of complexity of methods which might not be required or over-simplified assessments which could mislead decision-makers.

If we want the concept of ES to be used by decision-makers in the next decades, ES mapping needs to be of high quality and provide precise and reliable information. To provide a solid ground for decision-making, the selection of ES maps should not only be based on methods and data available, but also on the ES that are assessed, because the lack of consideration of relevant ES can significantly change ES trade-off assessments and the selection of alternative policy options.

Further Reading

Grêt-Regamey A, Weibel B, Kienast F, Rabe S-E, Zulian G (2015) A tiered approach for ecosystem services mapping. Ecosystem Services 13: 16-27.

Martinez-Harms MJ, Balvanera P (2012) Methods for mapping ecosystem service supply: a review. International Journal of Biodiversity Science, Ecosystem Services & Management 8: 17-25.