

# Land Management and Ecosystem Services

## How Collaborative Research Programmes Can Support Better Policies

*Land management decisions can be improved by understanding ecosystem services. Yet, existing ecosystem services studies vary too much to allow for general insights. Collaborative research programmes can reduce that variability and improve the prospects of a successful synthesis, ultimately leading to better land management policies.*

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#### Abstract

Land management, the organisation of the use and development of land, is an important instrument for addressing problems of rising greenhouse gas emissions and loss of natural resources. Yet, natural-social systems in which land management policies are implemented are poorly understood, thus decreasing the effectiveness of these policies. Local studies provide valuable insights, though only for the local conditions prevalent during the investigated period. Synthesising local studies in order to generalise results is impaired by the variety of local conditions. Collaborative research programmes may prevent some of these problems. They support the share of insights across temporal, ecological and spatial-economic contexts. On the basis of existing literature, we identify the challenges which face synthesis and demonstrate how a German research programme attempts to address some of them.

#### Keywords

collaborative research, ecosystem services assessment, land use policy

Changing patterns, extent and intensity of land use exerts pressure on natural landscapes and ecosystems (Sala et al. 2000, Ellis and Ramankutty 2008, Butchart et al. 2010). Increasing demand for food commodities from emerging markets as well as demand for biofuel will further stimulate agricultural expansion (Lambin and Meyfroidt 2011, Tilman et al. 2011). Yet, as climate change causes shifts in regional rain patterns, it will become necessary to adapt water use in all sectors, including agricultural irrigation needs (WWC 2009). At the same time, agriculture and water use will have significant effects on biodiversity and supporting ecosystems (Nellemann and Corcoran 2010, MA 2005 a). Above all, changes in land use can affect greenhouse gas emissions and storage (e.g., Fargione et al. 2008, Lapola et al. 2010). Land management, which we define as the organisation of the use and development of land and its natural resources, is therefore a central issue to identify sustainable development paths for interrelated natural and social systems. Designing land management policies that meet the various demands placed on land, e.g., the provision of freshwater, will pose a difficult challenge for the coming decades.

The concept of ecosystem services, i.e., the benefits humans derive from ecosystem goods and functions, is often seen as a means to provide clearer insight into the economics of conflicting land management goals (Perrings et al. 2010, Balmford et al. 2011). Understanding welfare gains and losses from changes in

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land management can help policy makers to design policies that address undesired welfare changes. This may lead to a more equitable distribution of the economic impact of new land management policies as well as a more sustainable use of natural resources (TEEB 2009).

The implementation of ecosystem services in the development of land management policies is not without its problems (e.g., Daily et al. 2009). Seppelt et al. (2011) analysed a literature database spanning a decade of ecosystem services research. They realised that comparisons were impaired by a lack of consistency in the methodologies employed. This is due to the fact that different stakeholders in different socio-economic and institutional contexts interact in various ways with the land available and the environment. Researchers are often forced to focus on particular aspects of a complex reality, such as the dynamics of an ecological subsystem or the economic value of marketable natural resources. Moreover, these aspects are often analysed using scientific techniques that are suited to the prevailing conditions or expertise of the scientific team. Máčka et al. (2011) suggest that results are more sensitive to such differences in the methodologies applied than to measurement errors.

Since ecosystem services studies differ so much in terms of these contextual and technical aspects, it is difficult to judge their individual scientific and political value. When ecosystem services studies lead to new land management policies with beneficial effects for local environmental and economic conditions (see Turner and Daily 2008 for high-profile examples), there is no way of determining whether these benefits were caused by chance or accurately applied science. In fact, it is not always clear if such beneficial effects arise at all (FAO 2007, Huitema and Bouma 2011). In order to address these concerns, a synthesis across multiple studies is needed. To this day, there is no common framework to organise the data and findings necessary to develop insights that extend beyond the local context (Troy and Wilson 2006, Ostrom 2009). Liu et al. (2010) add that the need for organised data is ever more crucial for studies that look at coupled, rather than isolated systems. As countries that are currently still rich in natural resources continue to develop economically, cross-border effects of global trade will also become an increasingly relevant issue.

The science of ecosystem services could be a useful basis for the design of land management policies. However, this implies highlighting and reducing the differences between ecosystem services studies in all their aspects. Only then can syntheses yield meaningful results that may help ecosystem services studies guide local land management, lead to better insight into policy transfer, and help address non-local effects of new policies where necessary.

This paper presents current research on the differences between ecosystem services studies. It then identifies means by which collaborative research programmes, in which individual projects actively try to cooperate and benefit from each other, can reduce that variability. Finally, it illustrates how these means are applied in a new German research programme, *Sustainable Land Management*.<sup>1</sup>

## Current Research on Ecosystem Services Studies

### Differences between Ecosystem Services Studies

We have based our study on the recent publication lists of governmental, scientific and applied science institutes active in the field of ecosystem service research. The reports chosen identify differences between ecosystem services studies as well as their causes and make recommendations for future research (MA 2005 a, b, HC 2008, ICSU et al. 2009, EPA 2009, TEEB 2010). We have excluded both reports that explain ecosystem services studies to practitioners or businesses (e.g., WRI 2008, Ash et al. 2009) and those that describe assessments of national ecosystems (Searle and Cox 2009, UK NEA 2011) because they do not discuss methodological consistency between individual studies. For the same reason, we do not take into account influential papers from the peer-reviewed literature, such as Cowling et al. (2008), Fisher et al. (2008), and Carpenter et al. (2009).<sup>2</sup> Our findings can be grouped into three main areas of concern: *data and indicators, socio-economic context and valuation*, as well as *scale considerations*.

**First**, differences in the collection of data and the use of indicators for ecological processes are an important reason why ecosystem services studies are difficult to compare. The scientific understanding of ecological processes is limited especially where thresholds at which these processes change dramatically are concerned. Every study employs a different way of dealing with this aspect, be it by choice or by necessity. Researchers working in otherwise comparable regions may also focus only on processes or methods with which they are familiar. They may prefer, for instance, remote sensing data to experimental plots, or hydrology to nutrient cycling (HC 2008, EPA 2009). A wide range of ecological indicators are produced in this way. Access to existing data may be restricted to some privileged research groups (MA 2005 a, b). Moreover, data sets that are available may contain gaps. They may have been collected using methods and indicators that are inconsistent over time, or they may exclude ecological processes that are in fact important (HC 2008, EPA 2009). For similar reasons, modelling of ecological processes will also differ between ecosystem services studies.

<sup>1</sup> The BMBF-funded research programme *Sustainable Land Management* consists of two modules, A and B, which respectively consider international and German examples. The authors are responsible for the scientific coordination of the regional projects in Module A, *Interactions Between Land Management, Climate Change and Ecosystem Services*. For more information, visit <http://modul-a.nachhaltiges-landmanagement.de/en/module-a>. The Leibniz Centre for Agricultural Landscape Research is coordinating the research projects in Module B, *Innovative System Solutions for Sustainable Land Management*. Whereas Module A aims at generating the knowledge needed for decision making at regional levels, Module B focuses on the development of technologies, system solutions and policy strategies.

<sup>2</sup> Searching the peer-reviewed literature, we found no publications on the differences between ecosystem services studies, the reliability of their results or their impact on the design of land management policies.

**Second**, comparable problems occur when collecting data about socio-economic context as well as determining the economic role and monetary value of ecosystem services. Institutional settings may affect access to data and even the ability to gather it (MA 2005 b). The policy options that can be suggested for better land management are co-determined by institutions: in hierarchical societies it is unlikely that policy changes can be implemented if the groups in power oppose them. Furthermore, the economic role and monetary value of ecological processes differ according to a wide variety of social perspectives. The importance of the same ecological process, e. g., water purification, will be viewed quite differently by people who buy bottled water than by those who depend on a local well (EPA 2009, TEEB 2010). Even when its importance is perceived similarly, the method used to assess the monetary value of an ecological process may have a large impact on the outcome of an ecosystem service study (TEEB 2010).

**Third**, scale considerations, both spatial and temporal, are a source of variability between ecosystem services studies. Spatial scale is an important determinant of whether an ecological process provides an ecosystem service or not (MA 2005 a). The food from mangrove forests will be important to those living near it, but that role will diminish as the study expands inland. Temporal scale may have several effects on studies. A long-term perspective allows researchers to assess slow-moving dynamics, but may obscure faster processes. Furthermore, the uncertainty of predicted outcomes increases exponentially as the time frame expands. Preferences for ecosystem services may be static in the short run, but will change as ecological thresholds are reached or new technologies become available. The balance of costs and benefits of land management policies changes with both the time scale and discount rate used (TEEB 2010).

**In sum**, all these issues provide an illustration of how the results of ecosystem services studies can be affected by variables other than the underlying ecological and social systems. Results should be correlated with other studies to determine their credibility. Yet, such a synthesis is restricted by the very same sources of variety, which are usually poorly documented. For example, there is often no way of knowing whether an ecosystem service is absent from a study because it is locally unimportant or because the data were not available or collected. Similarly, it is very difficult to judge whether ecological data from field experiments are substantially more reliable than indicators derived from remote sensing data. Consequently, the quality and robustness of results cannot be reliably assessed even though there is no doubt that all researchers aim to produce trustworthy results.

### Recommendations for Improving the Science and Practice of Ecosystem Services Studies

Following the scientific reports reviewed, one recommendation is to use a single conceptual framework for all studies, adapted to local conditions where necessary (MA 2005 a). Indeed, the universal application of one framework, provided adaptations are

documented, would be a big step toward making studies more comparable (Seppelt et al. forthcoming). Another suggestion is to acknowledge the uncertainty inherent to modelling interacting ecological and socio-economic systems (EPA 2009, TEEB 2010). This could take the form of statistical analysis of study results, but using contrasting scenarios would be a first step. The reports also stress the need for a better understanding of ecosystems and their thresholds (MA 2005 a, b, ICSU et al. 2009, EPA 2009, TEEB 2010). It is, however, hard to imagine achieving this without better data to connect ecological changes to changes in land management.

Much depends on better data and indicators about ecological processes becoming available. Without time series data, relating ecological change to changes in land management is based on one or only a few periods and this will hinder analysis of system dynamics. Producing better data requires regular, technically consistent and long-term monitoring of ecological processes (HC 2008, ICSU et al. 2009). Given such data, it will be possible to develop small sets of indicators that are relevant and easy to understand (MA 2005 b, EPA 2009). Yet, while the need to adapt indicators to the study context is clear, indicators should be analysed for their commensurability. Because data sets that would allow for this comparison are rare, we recommend an open exchange of well-documented data. This enables researchers to determine whether different studies can be included in one data set for comparison (EPA 2009).

Similar recommendations apply to data about socio-economic context and valuation, although for some variables, e. g., land use change and fertiliser use, data may be more readily available. Moreover, complications arise when moving from the description of ecological dynamics to the establishment of the monetary value of that change. Several reports recommend adapting concepts of value to local culture and uncover the economic benefits that ecological processes provide (EPA 2009, ICSU et al. 2009, TEEB 2010). A common assessment framework would serve as a good starting point. This would enable researchers to notice the absence of an ecosystem service or the presence of an uncommon one. A further issue arises with the monetisation of ecosystem services. The technique used to elicit value can have a significant impact on the results. EPA (2009), ICSU et al. (2009), and TEEB (2010) emphasise that improved techniques are required to ensure that the valuation of ecosystem services, in similar contexts, will be more comparable.

As for scale considerations, the MA (2005 a, b) proposes the use of nested scenarios that describe the system dynamics on two or more spatial scales. This allows for the identification of effects of land management policies that would not become apparent when considering only one scale, or of non-local stakeholders who affect local well-being. Local policies can then be designed to prevent negative effects elsewhere. When using nested scenarios, methods for value transfer and up- or downscaling of results are needed, such as informing and involving stakeholders at multiple scales, smart selection of ecosystem services that provide benefits at multiple scales, and statistical techniques (MA 2005 a, b, >

EPA 2009, TEEB 2010). Furthermore, methods for upscaling or value transfer can guide ecosystem services studies when time and funding are not sufficient for a complete assessment.

Many of the recommendations in this section address issues that individual studies typically encounter. There are common themes that can be developed to ensure more coherence among ecosystem services studies.

## Synthesis and Collaborative Research Programmes

### Improving Conditions for Synthesis

Collaborative research programmes can be used to reduce the differences between individual studies and promote the conditions for successful synthesis, which are the keys for the transfer of results. Large research programmes usually have an administrative group that manages the flow of information. Such a group may also handle the scientific coordination of the individual studies.

Understanding the local ecology will be an important goal for ecosystem services studies. This entails taking into consideration the diversity in data collection as well as the indicators and modelling approaches. A collaborative research programme cannot achieve this, nor can it prescribe research methods in any detail. What it can do though, is to facilitate discussion about methods and indicators by providing the infrastructure necessary for data exchange. For individual studies, it will be easier to compare results and test each other's methods. If significant differences appear, the infrastructure allows for the exploration of their causes.

Similarly, a collaborative research programme can support some commensurability of data on socio-economic context and valuation. It could encourage the use of a method that is identical across all studies for any given ecosystem service. In this way, a more useable source of valuation data would be generated. A collaborative research programme is also able to assist studies with the identification and selection of stakeholders, the process of their involvement, and the setting of achievable goals. This will reduce the impact that different levels of experience with stakeholder interaction have on the outcomes.

Individual studies are furthermore likely to develop story lines for scenarios or employ different models to quantify them. Within a collaborative research programme, it is possible to develop consistent scenarios. If each study has a set of boundary conditions consistent with the other studies, then all studies are more comparable. Provided that ecological processes can be modelled on the overarching spatial scale as well, each study can perform a nested assessment, and analyse differences between scales. Exchanging ideas and results allows studies to consider and compare results from other studies. This will improve the understanding of value transfer as well as up- and downscaling techniques.

Two important recommendations have so far remained unaddressed. One is to use a common framework for ecosystem services studies, which would arguably be ideal. Current knowledge on ecosystem services studies, however, is too limited for a collab-

orative research programme to prescribe a more detailed framework than one would find in, e.g., Cowling et al. (2008), Fisher et al. (2008), and Carpenter et al. (2009). The other recommendation is to assess the uncertainties inherent in ecosystem services studies. Here collaborative research programmes can help to set up an infrastructure for data exchange supporting comparative analyses of data and methods that would otherwise be difficult to perform. To make the most of it, a collaborative research programme should also continuously look for and promote opportunities for cooperation.

### The German Sustainable Land Management Programme

In November 2010, the German Federal Ministry for Research and Education (BMBF) launched the collaborative *Sustainable Land Management* research programme. It aims to improve the understanding of interacting ecological and socio-economic systems, and to help design better land management policies. Other institutes, such as the UK Department for Environment, Food and Rural Affairs (Defra)<sup>3</sup> and the US Environmental Protection Agency (EPA)<sup>4</sup>, have research programmes with comparable aims that build on experience and results from previous, isolated projects. However, the BMBF research programme is unique, because a synthesis of all funded studies was an important part of its design. The *Sustainable Land Management* programme comprises twelve five-year regional projects conducted in 13 countries across the world (see box 1).<sup>5</sup> There is also a coordinating project, *Global Assessment of Land Use Dynamics, Greenhouse Gas Emissions and Ecosystem Services (GLUES)*, that aims to develop scientific methodologies and synthesis. It will both improve the transferability of results and the assessment of cross-border effects.

On the one hand, the regional projects show similarities, starting with common drivers of change, such as population growth, developments in economic markets, and climate change. All projects will assess at least three greenhouse gases. There is also a distinct overlap in the ecosystem services that will be considered, such as food production, fresh water supply and climate regulation.

On the other hand, the regional projects showcase the above mentioned factors that complicate synthesis (see table, p. 60). The spatial scale of the projects ranges from a few square kilometres to one million hectares. A few projects have not yet decided on a time horizon for their scenarios. The manner in which ecological systems will be assessed also varies. Some projects have already selected a set of indicators, whereas others will discuss this with stakeholders. A few projects will consider ecological dynamics near thresholds, which will yield different results compared to projects that do not. The envisioned outcomes of the projects also vary, from providing better local data to influencing in-

<sup>3</sup> [www.defra.gov.uk/environment/policy/natural-environ/research/international-research.htm](http://www.defra.gov.uk/environment/policy/natural-environ/research/international-research.htm)

<sup>4</sup> [www.epa.gov/ecology](http://www.epa.gov/ecology)

<sup>5</sup> Three studies, COMTESS, LEGATO and *The Future Okavango*, will compare multiple neighbouring countries (see table, p. 60).

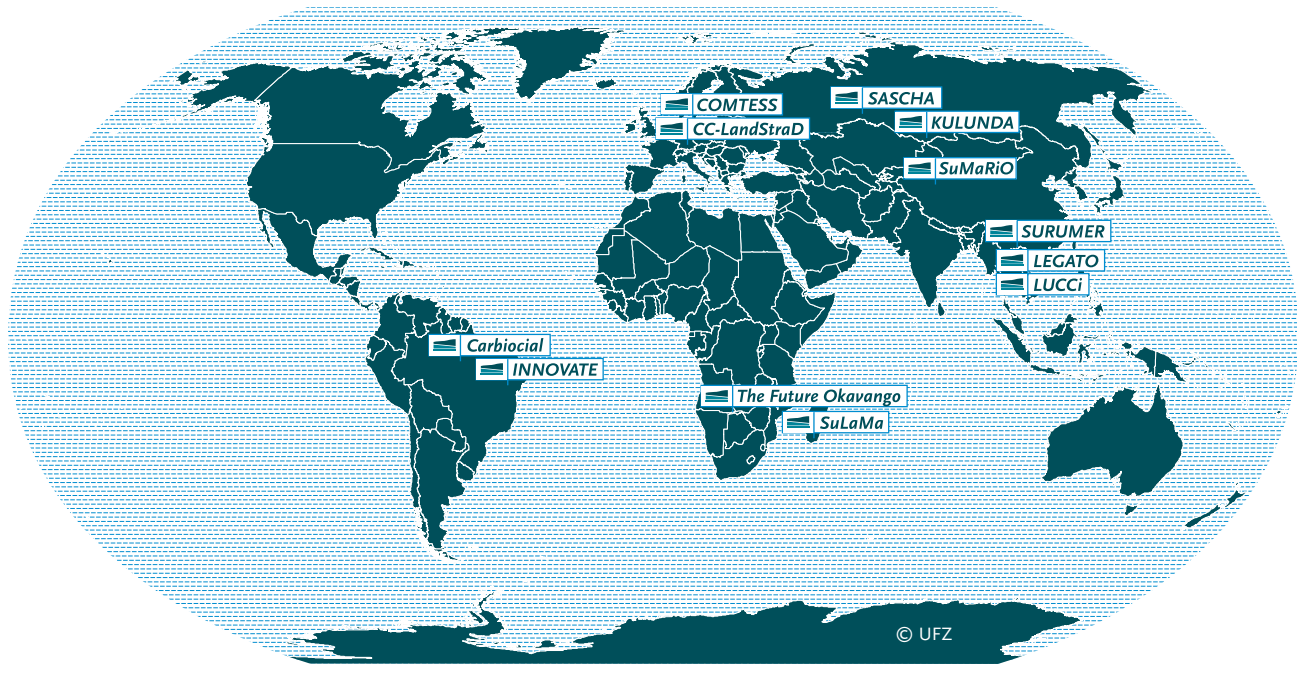


## BOX 1:

## Regional Projects within the German Collaborative Research Programme

Across four continents, twelve regional projects work on questions of sustainable land management. The studies focus on regions severely affected by climate and structural-demographic changes.

<b>Carbiocial:</b>	carbon sequestration, biodiversity and social structures in Southern Amazonia: models and implementation of carbon-optimized land management strategies	<b>LEGATO:</b>	land use intensity and ecological engineering: assessment tools for risks and opportunities in irrigated rice based production systems
<b>CC-LandStraD:</b>	interdependencies between land use and climate change: strategies for a sustainable land use management in Germany	<b>LUCCI:</b>	land use and climate change interactions in the Vu Gia Thu Bon river basin, Central Vietnam
<b>COMTESS:</b>	sustainable coastal land management: trade-offs in ecosystem services	<b>SASCHA:</b>	sustainable land management and adaptation strategies to climate change for the Western Siberian corn-belt
<b>INNOVATE:</b>	interplay among multiple uses of water reservoirs via innovative coupling of substance cycles in aquatic and terrestrial ecosystems	<b>SuLaMa:</b>	participatory research to support sustainable land management on the Mahafaly plateau, Madagascar
<b>KULUNDA:</b>	How to prevent the next "global dust bowl"? Ecological and economic strategies for sustainable land management in the Russian steppes: a potential solution to climate change	<b>SuMaRiO:</b>	sustainable management of river oases along the Tarim River, China
		<b>SURUMER:</b>	sustainable rubber cultivation in the Mekong Region – development of an integrative land-use concept in Yunnan Province, China
		<b>The Future Okavango:</b>	scientific support for sustainable land and resource management in the Okavango basin



ternational policies (see box 2, p. 61, for a more detailed description of two projects). Accordingly, the stakeholders involved display different characteristics.

The task of the coordinating group *GLUES* is to monitor and contain the differences between the regional projects. This benefits both the synthesis and the regional research. Only when the differences are reduced can regional projects compare their results, and then a serious attempt at synthesis can be made. Reducing these differences is based on three pillars: consistent scenarios, support for stakeholder activities, and open data exchange.

All regional projects will have a set of global mid-term and long-term scenarios made available to them. These scenarios in-

clude a range of climate change and policy options that could affect global economic developments. The storylines for the mid- and long-term scenario sets are internally consistent and will furthermore provide quantified boundary conditions for the projects. Before quantification can be initiated, an extensive dialogue and exchange between the coordinating and regional projects ensures that specific regional storylines are incorporated into the global scenarios. The global models will also produce predictions for a set of ecological processes, such as water availability, primary production and carbon sequestration. Nested scenarios can thus be developed and techniques for scaling and value transfer investi-



**TABLE:** Within the collaborative research programme, *Sustainable Land Management*, the regional projects show differences in some characteristics, e. g., spatial and temporal scale, ecological indicators, and socio-economic context, which complicate synthesis (n. s. = not explicitly specified in project proposal). The task of the coordinating group *GLUES* is to monitor and contain the differences between the regional projects.

project	region, area	land management conflict	scenario time span	ecological indicators	stakeholder involvement/ policy contribution
<i>Carbiocial</i>	<ul style="list-style-type: none"> <li>■ BR</li> <li>■ three study regions</li> <li>■ 25,000–200,000 km<sup>2</sup></li> </ul>	<ul style="list-style-type: none"> <li>■ various types of agriculture</li> <li>■ conservation</li> </ul>	2100	<ul style="list-style-type: none"> <li>■ stocks of carbon and organic matter</li> <li>■ yield variance</li> </ul>	<ul style="list-style-type: none"> <li>■ individual level</li> <li>■ regional to national level</li> <li>■ international level</li> <li>■ <i>decision support system</i></li> <li>■ <i>online data</i></li> <li>■ <i>print media</i></li> </ul>
<i>CC-LandStraD</i>	<ul style="list-style-type: none"> <li>■ DE</li> <li>■ three study regions</li> <li>■ 4,000–357,000 km<sup>2</sup></li> </ul>	<ul style="list-style-type: none"> <li>■ agriculture</li> <li>■ industrial</li> <li>■ residential</li> <li>■ conservation</li> </ul>	2030	<ul style="list-style-type: none"> <li>■ critical loads</li> </ul>	<ul style="list-style-type: none"> <li>■ state to federal level</li> <li>■ <i>co-developing feasible policies</i></li> </ul>
<i>COMTESS</i>	<ul style="list-style-type: none"> <li>■ NL, DE, DK</li> <li>■ four study regions</li> <li>■ 76 km<sup>2</sup></li> </ul>	<ul style="list-style-type: none"> <li>■ coastal area policies</li> </ul>	n. s.	<ul style="list-style-type: none"> <li>■ variability of ecosystem processes</li> <li>■ biodiversity</li> </ul>	<ul style="list-style-type: none"> <li>■ individual to national level</li> <li>■ <i>awareness raising</i></li> </ul>
<i>INNOVATE</i>	<ul style="list-style-type: none"> <li>■ BR</li> <li>■ one reservoir catchment area</li> <li>■ 377,000 km<sup>2</sup></li> </ul>	<ul style="list-style-type: none"> <li>■ water reservoirs</li> <li>■ aquaculture</li> <li>■ food</li> <li>■ energy supplies</li> </ul>	n. s.	<ul style="list-style-type: none"> <li>■ carbon and nitrogen cycles</li> </ul>	<ul style="list-style-type: none"> <li>■ all governance levels</li> <li>■ <i>decision support approach</i></li> </ul>
<i>KULUNDA</i>	<ul style="list-style-type: none"> <li>■ RU</li> <li>■ three regions</li> <li>■ 60,000 km<sup>2</sup></li> </ul>	<ul style="list-style-type: none"> <li>■ agriculture</li> <li>■ post-Soviet changes</li> </ul>	2030–2050	<ul style="list-style-type: none"> <li>■ stocks of carbon</li> <li>■ yield increase</li> <li>■ carbon trade</li> <li>■ grain production</li> </ul>	<ul style="list-style-type: none"> <li>■ local to regional level</li> <li>■ <i>communication platform</i></li> <li>■ <i>agricultural capacity development</i></li> <li>■ <i>farm-to-farm schools</i></li> </ul>
<i>LEGATO</i>	<ul style="list-style-type: none"> <li>■ VN, MY, PH</li> <li>■ 14 study regions</li> <li>■ 16 km<sup>2</sup></li> </ul>	<ul style="list-style-type: none"> <li>■ agriculture</li> <li>■ conservation</li> </ul>	2100	<ul style="list-style-type: none"> <li>■ yield variance</li> <li>■ biocontrol</li> </ul>	<ul style="list-style-type: none"> <li>■ local to regional level</li> <li>■ international level</li> <li>■ <i>online data availability</i></li> </ul>
<i>LUCCi</i>	<ul style="list-style-type: none"> <li>■ VN</li> <li>■ two study regions</li> <li>■ up to 10,350 km<sup>2</sup></li> </ul>	<ul style="list-style-type: none"> <li>■ agriculture</li> <li>■ hydropower</li> <li>■ infrastructure</li> <li>■ conservation</li> </ul>	2050	<ul style="list-style-type: none"> <li>■ to be discussed with stakeholders</li> </ul>	<ul style="list-style-type: none"> <li>■ community to state level</li> <li>■ <i>strategic policy formulation</i></li> </ul>
<i>SASCHA</i>	<ul style="list-style-type: none"> <li>■ RU</li> <li>■ three study regions</li> <li>■ 1,200 km<sup>2</sup></li> </ul>	<ul style="list-style-type: none"> <li>■ agriculture</li> <li>■ biodiversity</li> </ul>	2100	<ul style="list-style-type: none"> <li>■ carbon stocks</li> <li>■ GHG emissions</li> <li>■ hydrology and nutrient flows</li> <li>■ biodiversity</li> <li>■ livestock densities</li> </ul>	<ul style="list-style-type: none"> <li>■ local to regional level</li> <li>■ <i>information system</i></li> <li>■ <i>training</i></li> </ul>
<i>SuLaMa</i>	<ul style="list-style-type: none"> <li>■ MG</li> <li>■ one study region</li> <li>■ 7,500 km<sup>2</sup></li> </ul>	<ul style="list-style-type: none"> <li>■ agriculture</li> <li>■ mining</li> <li>■ conservation</li> </ul>	n. s.	<ul style="list-style-type: none"> <li>■ multiple indicators per ecosystem service</li> </ul>	<ul style="list-style-type: none"> <li>■ local to international level</li> <li>■ <i>stimulating alternative livelihoods</i></li> </ul>
<i>SuMaRio</i>	<ul style="list-style-type: none"> <li>■ CN</li> <li>■ one study region</li> <li>■ 1,000,000 ha</li> </ul>	<ul style="list-style-type: none"> <li>■ agriculture</li> <li>■ water extraction</li> <li>■ conservation</li> </ul>	2050	<ul style="list-style-type: none"> <li>■ abundance of floods</li> <li>■ desertification</li> <li>■ soil salinity</li> <li>■ habitat change</li> <li>■ crop production</li> </ul>	<ul style="list-style-type: none"> <li>■ regional level</li> <li>■ <i>decision support system</i></li> </ul>
<i>SURUMER</i>	<ul style="list-style-type: none"> <li>■ CN</li> <li>■ two study regions</li> <li>■ 19,700 km<sup>2</sup></li> </ul>	<ul style="list-style-type: none"> <li>■ plantations</li> <li>■ biodiversity conservation</li> </ul>	n. s.	<ul style="list-style-type: none"> <li>■ n. s.</li> </ul>	<ul style="list-style-type: none"> <li>■ local level</li> <li>■ <i>alternative production methods and water use</i></li> </ul>
<i>The Future Okavango</i>	<ul style="list-style-type: none"> <li>■ AO, NA, BW</li> <li>■ four study regions</li> <li>■ 430,000 km<sup>2</sup></li> </ul>	<ul style="list-style-type: none"> <li>■ agriculture</li> <li>■ water extraction</li> </ul>	n. s.	<ul style="list-style-type: none"> <li>■ to be discussed with stakeholders</li> </ul>	<ul style="list-style-type: none"> <li>■ local to international level</li> <li>■ <i>local-national policy interaction</i></li> </ul>

## BOX 2:

Two Regional Projects Illustrated – *SASCHA* and *The Future Okavango (TFO)*

The following two project descriptions illustrate the integrative, interdisciplinary and regional perspectives of the individual studies as well as the overall objectives of the collaborative research programme.

**SASCHA – Sustainable Land Management and Adaptation Strategies to Climate Change for the Western Siberian Corn-belt**

The steppes and southern forests of Western Siberia are of global significance for carbon sequestration and biodiversity. They are also crucial for Russia if it wants to be a bigger player in the global markets for food and energy crops. The conversion of steppe soils and peat lands into agricultural land will release great amounts of greenhouse gases and affect biodiversity negatively. However, there is hardly any local awareness of these issues since regional problems are dominant in the area. The German-Russian project *SASCHA* will provide basic knowledge and management tools to cope with these far-reaching changes. This includes scientific insight into Western Siberia's contribution to the global carbon budget, but also the development of a system to monitor land-use change. Regional stakeholders, used to top-down decision making, will be provided with practical tools to make farm-level agriculture more sustainable. In this way, *SASCHA* aims to mitigate negative climate change effects and preserve Western Siberia's unique biodiversity without hindering the economic development of Western Siberia.

Forest steppe south of Tyumen, Western Siberia, June 2011.

This species-rich habitat on carbon-rich Chernozem soils is important for the global climate balance, but also imminently threatened by conversion into arable land for food and biofuel production.



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**TFO – Scientific Support for Sustainable Land and Resource Management in the Okavango Basin**

The Okavango basin with its variety of savannah woodlands and wetland ecosystems linked by the central lifeline of the Okavango River faces population growth, increasing water and resource use, agricultural depletion and loss of biodiversity. The German-African project *TFO* aims to support transboundary management plans for the Okavango region. It will develop scientific knowledge of the basin's ecosystem services and biodiversity as well as optimised strategies for sustainable land use. This offers a perspective of meeting the economic requirements of a growing indigenous population. However, communication with and involvement of local stakeholders is of major importance. Because the Okavango basin spans three countries, the participation of national decision makers in Angola, Botswana and Namibia is needed to strengthen the acceptance and implementation of strategies and policies. By actively supporting the various actors with scientific knowledge, *TFO* will contribute to the success of the international *Strategic Action Programme* for the Okavango basin.

Charcoal trading along the road from Menongue to Chitembo.

The unsustainable use of charcoal is a main driver of forest degradation in the upper Cubango catchment in Angola.



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For stakeholder involvement, the regional projects can draw on expertise available within the coordinating project. This support ranges from an early inventory of potential stakeholders to workshops helping researchers make the most of their discussions with stakeholders. The support provided reduces the risk of inexperience significantly affecting stakeholders' responses to the project and thus its outcomes.

The third and final pillar is formed by a Geodata Infrastructure. This is a web-based data portal through which the regional projects can make intermediate and final data available as well as access data from other projects. In fact, this database is open to everyone, not just to the partners in the *Sustainable Land Man-*

*agement* programme. All data owners must complete a meta-data form to ensure that anyone accessing a data set is aware of relevant features, such as its contents, spatial resolution, provenance, and contact person. If available, corresponding scientific publications are also linked.

## Discussion

The concept of ecosystem services can be an instrument for designing better land management policies. This paper has illustrated how circumstantial influences can affect the outcomes of

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ecosystem services studies. Each study produces unique outcomes and their quality, as a basis for land management policies, cannot be objectively established unless the comparability of studies improves. Building on a review of recent reports on ecosystem service research, this paper identified means by which collaborative research programmes can support synthesis.

Ecosystem services studies are inter- or transdisciplinary projects that combine scientific disciplines in their analysis of interacting ecological and socio-economic systems. In collaborative research programmes, a group of such projects tries to coordinate its research methods as much as possible. This reduces the differences between studies and improves the chances of a successful synthesis and comparison. In large collaborative research programmes, resources may be available to provide support for and actively promote such cooperation.

*Sustainable Land Management* is a step towards an ideal collaborative research programme. The German programme provides a web-based database that anyone can access and upload data to. It supports research projects in their identification of and interaction with stakeholders, and provides projects with a consistent set of quantified scenarios involving different economic and ecological boundary variables. These services will prevent some common discrepancies between ecosystem services studies and make it possible to analyse the impact of remaining ones.

Nevertheless, there remains a degree of variation between the projects in the *Sustainable Land Management* programme. To name three: the research projects consider varying sets of ecological indicators, and both the temporal and spatial scales of projects differ. Such differences could only have been eradicated through extensive upfront coordination of scientific goals and methods. That would have been unrealistic and, for reasons discussed in this paper, is currently undesirable. These differences represent a risk for the synthesis of the projects. They also provide an opportunity understanding the impact of these differences on results,

through mutual testing of research methods and comparison of outcomes in different contexts. This is a prerequisite for the development of up- or downscaling, and should yield further insight into the general validity and transferability of data, models and recommendations.

The projects within the *Sustainable Land Management* programme have officially committed themselves to cooperation. The process of scenario development, in which regional projects are able to discuss their wishes with the coordinating project, represents a first success in this endeavour. Research teams also have an intrinsic incentive for cooperation, as every question about validity and comparability of results may advance scientific discourse. Beyond these benefits, much depends on the willingness of people to actively pursue cooperation. Hence, an important contribution of the collaborative research programmes should be to facilitate, identify and promote opportunities for cooperation.

In conclusion, collaborative research programmes are an important part of improving the understanding of ecosystem services studies and the design of land management policies. The *Sustainable Land Management* programme represents a good step towards these goals, but it is only a first step: twelve projects are not enough to develop the insights and techniques championed in this paper. More collaborative research programmes are needed, each of which should build on previous lessons. Individual studies could seek cooperation with larger projects. The *Sustainable Land Management* programme has contacted projects that it is aware of and invites any programme or project to discuss potential cooperation. What ecosystem service science currently requires is data that can be compared. This could enable a better understanding of the complex interactions that land management scientists are confronted with.

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## A wie Aktionsplan

Wie und unter welchen Voraussetzungen kann eine Anpassung an den Klimawandel gelingen? Zahlreiche transdisziplinäre Forschungsprojekte widmen sich dieser Fragestellung. Die Herausgeber präsentieren Ergebnisse für einen Aktionsplan, der sich mit der Initiierung und Umsetzung von Anpassungsmaßnahmen auf lokaler oder regionaler Ebene befasst: Diskussionsbeiträge zur Climate Adaption Governance aus dem deutschsprachigen Raum.

B. Frommer, F. Buchholz, H. R. Böhm (Hrsg.)  
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## References

- Ash, N. et al. (Eds.). 2009. *Ecosystems and human well-being: A manual for assessment practitioners*. Washington, D. C.: Island.
- Balmford, A. et al. 2011. Bringing ecosystem services into the real world: An operational framework for assessing the economic consequences of losing wild nature. *Environmental and Resource Economics* 48: 161–175.
- Butchart, S. H. M. et al. 2010. Global biodiversity: Indicators of recent declines. *Science* 328: 1164–1168.
- Carpenter, S. R. et al. 2009. Science for managing ecosystem services: Beyond the Millennium Ecosystem Assessment. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)* 106: 1305–1312.
- Cowling, R. M. et al. 2008. An operational model for mainstreaming ecosystem services for implementation. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)* 105: 9483–9488.
- Daily, G. C. et al. 2009. Ecosystem services in decision making: Time to deliver. *Frontiers in Ecology and the Environment* 7: 21–28.
- Ellis, E. C., N. Ramankutty. 2008. Putting people in the map: Anthropogenic biomes of the world. *Frontiers in Ecology and the Environment* 6: 439–447.
- EPA (United States Environmental Protection Agency). 2009. *Valuing the protection of ecological systems and services: A report of the EPA science advisory board*. Washington, D. C.: EPA.
- FAO (Food and Agriculture Organization). 2007. *The global environmental facility and payments for ecosystem services: A review of current initiatives and recommendations for future PES support by GEF and FAO programs*. PESAL Paper Series 1. Rome: FAO.
- Fargione, J., J. Hill, D. Tilman, S. Polasky, P. Hawthorne. 2008. Land clearing and the biofuel carbon debt. *Science* 319: 1235–1238.
- Fisher, B. et al. 2008. Ecosystem services and economic theory: Integration for policy-relevant research. *Ecological Applications* 18: 2050–2067.
- HC (Heinz Center). 2008. *The state of the nation's ecosystems 2008*. Washington, D. C.: Heinz Center.
- Huitema, D., J. Bouma. 2011. *Discourse vs reality: Conservation and livelihoods in biodiversity hotspots around the world*. Amsterdam: Institute for Environmental Studies.
- ICSU (International Council for Science), UNESCO (United Nations Educational, Scientific and Cultural Organization), UNU (United Nations University). 2009. *Ecosystem change and human well-being: Research and monitoring priorities based on the Millennium Ecosystem Assessment*. Paris: ICSU.
- Lambin, E. F., P. Meyfroidt. 2011. Global land use change, economic globalization, and the looming land scarcity. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)* 108: 3465–3472.
- Lapola, D. M. et al. 2010. Indirect land-use changes can overcome carbon savings from biofuels in Brazil. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)* 107: 3388–3393.
- Liu, J. et al. 2010. Complexity of coupled human and natural systems. *Science* 317: 1513–1516.
- MA (Millennium Ecosystem Assessment). 2005 a. *Ecosystems and human well-being: Synthesis*. Washington, D. C.: Island.
- MA. 2005 b. *Ecosystems and human well-being: Multiscale assessments*. Washington, D. C.: Island.
- Máčka, Z., L. Krejčí, B. Loučková, L. Peterková. 2011. A critical review of field techniques employed in the survey of large woody debris in river corridors: A central European perspective. *Environmental Monitoring and Assessment* 181: 291–316.
- Nellemann, C., E. Corcoran (Eds.). 2010. *Dead planet, living planet: Biodiversity and ecosystem restoration for sustainable development*. Arendal: UNEP (United Nations Environmental Programme), GRID (Global Resource Information Database).
- Ostrom, E. 2009. A general framework for analyzing sustainability of social-ecological systems. *Science* 325: 419–422.
- Perrings, C. et al. 2010. Ecosystem services for 2020. *Science* 330: 323–324.
- Sala, O. E. et al. 2000. Global biodiversity scenarios for the year 2100. *Science* 287: 1770–1774.
- Searle, B., S. Cox. 2009. *The state of ecosystem services*. Boston: Bridgespan Group.
- Seppelt, R., C. F. Dormann, F. V. Eppink, S. Lautenbach, S. Schmidt. 2011. A quantitative review of ecosystem service studies: Approaches, shortcomings and the road ahead. *Journal of Applied Ecology* 48: 630–636.
- Seppelt, R. et al. Forthcoming. Form follows function? Proposing a blueprint for ecosystem service assessments based on reviews and case studies. *Ecological Indicators*.
- TEEB (The Economics of Ecosystems and Biodiversity). 2009. *The economics of ecosystems and biodiversity for national and international policy makers – Summary: Responding to the value of nature*. Wesseling: Welzel + Hardt.
- TEEB. 2010. *The economics of ecosystems and biodiversity: Ecological and economic foundation*. Washington, D. C.: Island.
- Tilman, D., C. Balzer, J. Hill, B. L. Befort. 2011. Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)* 108: 20260–20264.
- Troy, A., M. A. Wilson. 2006. Mapping ecosystem services: Practical challenges and opportunities in linking GIS and value transfer. *Ecological Economics* 60: 435–449.
- Turner, R., G. Daily. 2008. The ecosystem services framework and natural capital conservation. *Environmental and Resource Economics* 39: 25–35.
- UK NEA (United Kingdom National Ecosystem Assessment). 2011. *The UK National Ecosystem Assessment: Synthesis of the key findings*. Cambridge, UK: UNEP (United Nations Environmental Programme), WCMC (World Conservation Monitoring Centre).
- WRI (World Resources Institute). 2008. *Ecosystem services: A guide for decision makers*. Washington, D. C.: WRI.
- WWC (World Water Council). 2009. *Don't stick your head in the sand! Towards a framework for climate-proofing*. Marseilles: WWC.

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