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# Nexus thinking – how ecosystem services can contribute to enhancing the cross-scale and cross-sectoral coherence between land use, spatial planning and policy-making

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## ABSTRACT

The ecosystem service (ES) concept is acknowledged for its potential to support decision-making on various scales. Still, it lacks in practical implementation, particularly concerning spatial planning and land management – key aspects that lead to criticism in its applicability. ES in planning and decision-making can contribute to improve the quality of land use and management by integrating synergies, trade-offs and conflicts among economy, environment and societal goals. This opinion paper suggests a nexus approach that shows how ES can contribute to characterize the interactions between humans and nature on different temporal and spatial scales while integrating cross-scale effects in trade-off analyses. We discuss how our nexus approach can be implemented and contribute to revealing the interdependencies between policy sectors, spatial and land-use planning. We argue that thinking in terms of a nexus adds to an improved coherence across different policy sectors relevant for spatial planning. We conclude that only a strategic and concise use of ES throughout all decision levels will help to create maximum benefits for harmonizing policy, planning and management instruments supported by intervention measures for the sake of sustainable development.

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## 1. Introduction

Ecosystem services (ES) are acknowledged as an important concept for examination of the interactions between ecosystems and human well-being (MEA 2005; TEEB 2010). There is a growing amount of literature on linkages between natural capital and ES and approaches to value them (Spash, 2008a, 2008b; Bunse et al. 2015). This includes aspects such as ecological processes, pattern and functions as a basis for assessing and improving environmental policies, spatial planning and more generally sustainable land management (Burkhard et al. 2012; Fürst 2016). ES support a holistic understanding of relevant interactions between nature and human beings by revealing synergies and conflicts between environmental and socio-economic goals (Häyha and Franzese, 2014; Iverson et al. 2014). Furthermore, ES provide a comprehensive framework for addressing globally relevant questions of human well-being offering thereby a well-grounded basis for trade-off analyses that address compromises between competing land uses and resource demands, as well as conflicts between nature conservation and social–economic demands (Grêt-Regamey et al. 2013; Seppelt et al. 2013; Gonzalez-Redin et al. 2016). We suggest that using ES as a generic reference for assessing

alternative choices helps to facilitate planning and development decisions across administrative boundaries by analyzing the performance of policies, plans and land-use and management strategies in a wider social–ecological context so that, for instance, tele-coupling effects become visible (Liu et al. 2007).

Trade-off analyses are of particular relevance when it comes to policies and plans that aim at ensuring the provision of service bundles such as the equal availability and accessibility of staple food, drinking water and renewable energy resources (Schwenk et al., 2012; Gonzalez-Redin et al. 2016). Strategies that attempt to sustain or enhance the provision of such services often go along with critical environmental impacts that threaten the long-term capability of land and ecosystems to provide resources (Tilman et al. 2002). These impacts may not immediately trigger perceptible or measurable losses of land or ecosystem capacities and thus confine demands of future generations, whatever these may be (Godfray et al. 2010; Hussey and Pittcock, 2012). Consequently, trade-off analyses should make use of and combine qualitative and quantitative impact assessment methods to inform spatial planning and policy actors (Carpenter et al. 2009; Chan et al. 2012a; Gramfeld et al. 2013).

In support of exploring and overcoming such trade-offs, the approach of looking at the nexus between different and competing planning or policy objectives is increasingly used. A nexus approach requires systemic thinking and understanding of the complex linkages and feedback mechanisms in social–ecological systems for delivering integrated solutions, thus addressing key challenges in sustainable development (Liu et al. 2015). Most recently, an international scientific effort is underway to ensure an equitable access to food, energy and water (Future Earth Knowledge and Action Network ‘Food-Energy-Water’ Nexus, [www.futureearth.org/future-earth-water-energy-food-nexus](http://www.futureearth.org/future-earth-water-energy-food-nexus)) by connecting knowledge and bundling case studies to derive recommendations for sustainable resource management.

Food, (renewable) energy and water are important ES whose sustainable provision represents a key objective in planning on different scales, from ecosystem management to territorial planning at regional or national levels (De Groot et al. 2010). The benefits of bringing together ES and the nexus approach in environmental governance consist in urging the equal consideration of bundles of cultural, regulating and provisioning services (Bennett et al. 2009): in contradiction to the sustainability requirements, many ES implementation examples focus still only on single or very few ES while the consideration of multiple ES only started most recently (Benett and Chaplin-Kramer, 2016). Particularly cultural services, but also regulating services, which are related to so-called off-site effects from changing and adapting land uses, frequently run the risk of being perceived

economically less important. Reasons are that changes in their availability might not be relevant within the spatial borders of the system under analysis or might occur only in the future (Chan et al. 2012b; Sutherland et al. 2014). Consequently, addressing ES bundles in developing and consulting environmental policies, spatial planning and land-use strategies would contribute to ensuring sustainable development and growth on all scales and for current and future generations.

This opinion paper introduces a conceptual framework for the special issue ‘Nexus thinking – How ES concepts and practice can contribute balancing integrative resource management practices by facilitating cross-scale and cross-sectoral planning’. Its objective is to discuss how ES can be embedded in a nexus between nature, humanity and scales to build a bridge for their implementation in environmentally relevant policy sectors, spatial planning and land use (see also Rozas-Vasquez et al. 2017). With ‘nexus’, we understand in general the interconnectedness between human actions and nature’s reactions on different spatial scales (Figure 1), and in special between different levels in environmental decision-making (policies, spatial planning, land use and management; Figure 2). We consider our vision of embedding ES into such a nexus approach to be a crucial contribution toward enhancing usage of the ES concept by providing a suggestion how to connect ES better with the terminology, scales and instruments used in practice. We start by analyzing how the ES nexus can contribute to reveal scale effects that are relevant for recommending improved strategies in spatial

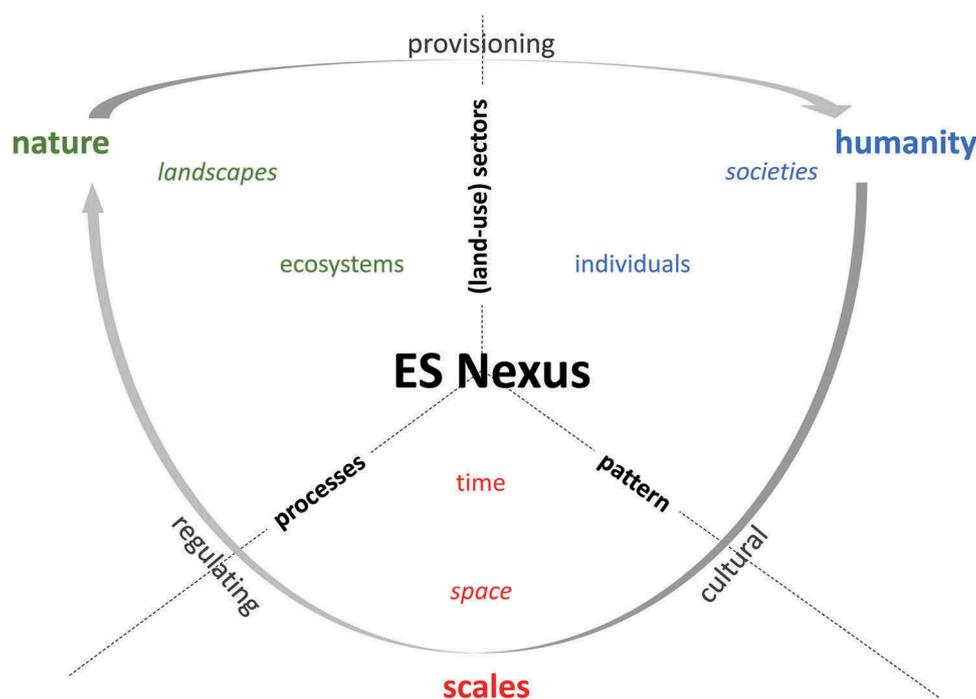
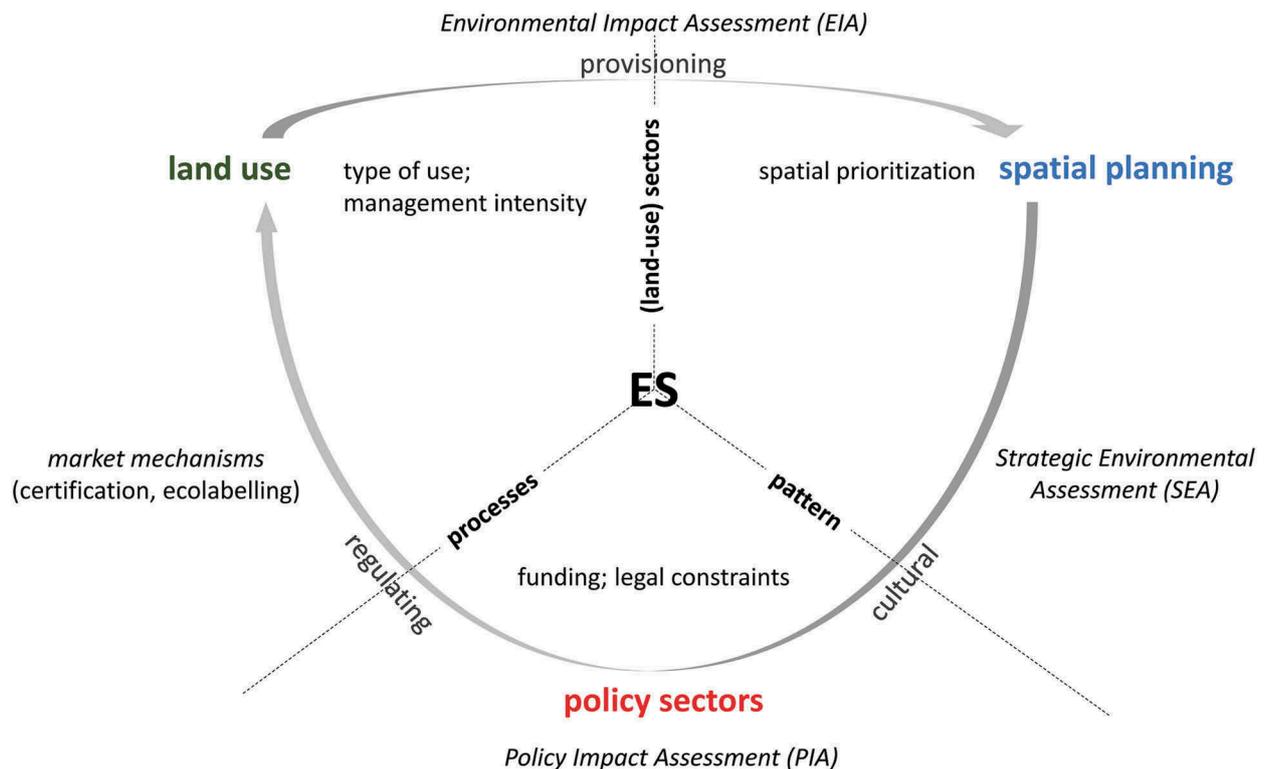


Figure 1. The ES nexus.



**Figure 2.** Implementing the ES nexus to enhance the coherence between policy making, spatial planning and land use.

planning and land use. Second, we discuss the role of actors in social–ecological systems, their interactions and dependencies and the resulting mutual impacts between societal and individual goals. Subsequently, we transform the nexus approach to the interaction of instruments and implementation measures between the policy, planning and land management level and discuss how coherence between these could be achieved by using ES. Finally, we assess not only the potentials but also limitations of our suggested approach. We conclude that a strategic and consistent use of ES on all decision scales is a precondition for taking full benefit of the huge potentials of ES for sustainable development.

## 2. Spatial and temporal scales connecting nature and humanity

We suggest extending the nexus approach by integrating the different components that produce ES in a manner that addresses particularly their interconnectedness (Figure 1). Concepts such as the so-called ES cascade (Haines-Young and Potschin, 2010; Potschin and Haines Young, 2011) are highly valuable for structuring how ecological processes, pattern and functions are related to the socio-cultural component of social–ecological systems which determine demand and consumption of services and thus how ES values are produced. Embedded in assessment frameworks such as DPSIR (Drivers-Pressures-State-Impact-Responses, Smeets and Weterings 1999) as

suggested, for instance, by Müller and Burkhard (2012), the ES cascade can be implemented to assess the quality and impacts of environmental plans and programs (Geneletti et al. 2016). However, there is still a need to provide a basis for appropriately characterizing the various feedback loops between nature and human beings on the various temporal and spatial scales where these happen. In the following subsections, we discuss the critical relevance of such interactions.

### 2.1. Social–ecological system boundaries and scales and their impact on ES supply capacities

A problem in developing environmental plans and policies consists in how to define meaningful system boundaries that address the ‘right and relevant’ decision makers and ensure that ecosystem processes and their multiple temporal and spatial scales are sufficiently taken into account. This is critical in planning and policy-making because plans and policies refer mostly to administrative boundaries (i.e. correspond to a jurisdiction level, such as a region or a municipality), but not to biophysical or socio-ethnological aspects that form a much more relevant and reliable reference to connect ES supply capacities and demands (Geneletti 2015). Assessments on a national, (world) regional or global scale as they are currently running in the context of the European Biodiversity Strategy (Maes et al. 2012) and in IPBES (Intergovernmental Panel for Biodiversity and

Ecosystem Services, Larigauderie and Mooney 2010) or have been delivered in the past through the Millennium Ecosystem Assessment (MEA 2005) provide a comprehensive overview on the state-of-the-art of natural ES supply capacities. Storylines that describe changes in relevant drivers such as climate change, global trade and markets or consumption habits enable one to analyze how ES supply capacities could change over time and thus provide important inputs for adjusting-related policies. However, such assessments do not necessarily include information on ES demands or flows as an important criterion for spatial decision-making (Mononen et al. 2016; Wolff et al. 2017). Furthermore, the ES supply capacities are often of purely theoretical nature. They do not incorporate restrictions that can arise from the physical accessibility of service-providing areas, legal regulations or land tenure with its huge impact on if and how ecosystems are managed (see e.g. Frank et al. 2015). Also, these kinds of large-scale assessments do not look in depth at human–nature interactions in real problem-solving contexts. Individual preferences, place-based values or taboos, cultural heritage or societal objectives play a key role and necessitate the application of scenarios related to the respective decision-making space to explore acceptable and feasible strategies for sustaining and enhancing ES (Seppelt et al. 2013).

Conducting ES assessments on more detailed scales such as landscapes, catchments or single ecosystems, as done in many case studies, ensures that decision-relevant information is provided (Fürst et al. 2014). A benefit of such assessments consists in the opportunity to incorporate how plans and policies interact with land-use and management strategies and their particular impacts on ES supply capacities (Van Oudenhoven et al. 2012). Moreover, the consideration of land-use or management strategies can be considered as a comprehensive proxy for ES demands and could contribute to understanding and interpreting spatio-temporal patterns of ES flows (Stürk et al., 2014). Particularly, land management strategies are developed against the background of the land owner's or land user's targets related to producing natural resources, mitigating related risks and accounting for societal demands by considering, for example, cross-compliance regulations or restrictions related to making use of public or private payments for ES (Fürst et al., 2013; Lorenz et al., 2013).

An aspect that is often not well addressed in ES assessments is that projections on ES supply capacities need to consider temporal ecosystem dynamics in order to sustainably cover ES demands (Birkhofer et al. 2015). Land managers are already making use of information on seasonal or long-term ecosystem dynamics for their day-to-day decisions and for

strategic planning. However, taking agricultural and forest land management as examples, both refer to largely different planning periods, reaching from intra-annual dynamics and interventions in agriculture to centuries in developing and managing forest ecosystems. This, however, creates the problem of how to properly integrate information of only these two land-use sectors in ES-based plans and programs that address, for instance, landscapes or administrative districts.

A solution for this problem consists in using scenario simulations. These could help to appraise the range in which future ES supply capacities vary and help to explore adaptation opportunities within and across sectors such as agriculture and forestry through varying management intensity and related land demands. Planning recommendations or policies thereby could be derived that avoid favoring one land-use sector at the expense of the other. However, this kind of scenario is only rarely implemented in integrative studies, planning or policy-making (e.g. Newton et al. 2013).

On the other hand, assessments in a limited spatial or ecosystemic context run the risk of underestimating or even excluding the impacts of place-specific parameters (e.g. geo-topographical particularities) and of landscape configuration (Frank et al. 2011). Taking again agriculture and forestry as examples, their focus on management planning units (parcels in agriculture, stands in forestry) might provoke an insufficient consideration of eco-hydrological processes happening on larger scales (e.g. Wei et al. 2012). Off-site effects, such as flooding, loss of habitats or step-stones that connect habitats, nitrate or phosphorus release to ground and surface water, are a co-product of size, form and location of ecosystems and the related management practices (Mandle and Tallis, 2016). Synergy effects or limitations in ES supply capacities arise through mutual impacts along ecosystem borders that can enhance or disturb, for instance, matter and water balances. Consequently, Temorshuizen and Opdam (2009) suggested the use of 'landscape services' to emphasize the scale dependencies of ES.

## 2.2. Human interventions into nature and ES impacts

The actors in different land-use sectors such as agriculture, forestry or the built environment can be characterized as socio-culturally and economically connected subsets of individuals in societies (social networks) whose engagement is oriented toward efficient management of natural resources (Bodin and Tengö, 2012; Bodin and Crona, 2009). The interactions of single actors and social networks with nature comprise short-term interventions on an ecosystem

scale (management) and the reorganization of spatial pattern and structures on meso- to macro scales (planning) (Bryan and Crossman 2008).

Both types of interventions frequently prioritize the supply of specific services, such as the production of food, fodder, fuel wood, construction materials (*provisioning services*) or the enhancement of the recreational and touristic value (*cultural services*). This can result in trade-offs between the targeted services (Bennett et al. 2009). For instance, increasing sizes of agricultural parcels together with highly intense management bring up more homogenous landscape patterns that might be perceived as being less inspiring, attractive for leisure activities or conversant (Frank et al. 2014). Other trade-offs can be implemented for *regulating services*, such as flood- or water-erosion protection, by intervening in the size and spatial connection of hydrological response units (Flügel 1995). Such trade-offs are to be found temporally or spatially close to the intervention and might show up at a greater distance (off-site) or be delayed. In response, also the supply capacities for provisioning services can be impacted, for instance, through degradation processes (Tengberg and Torheim 2007).

Regulative and cultural services whose supply is not exclusive in the decision space of one single land-use sector, or which are not relevant for a specific actor or social network, can be addressed through governance mechanisms. Appropriate mechanisms can span from building consensus and agreeing upon actions among several networks or network agents to legally binding prioritization of services supply areas in regional and landscape planning (Steingröver et al. 2010; Frank et al. 2014; Fürst et al. 2016).

Trade-offs can also be introduced between different social groups or communities on a regional and global scale. For instance, the increasing land consumption through agriculture constrains forest communities in maintaining their forest land and its provision of timber, forest food or pharmaceuticals (Li 1999; Foley et al. 2005).

Also, societal goals in securing, for instance, food, (bio)energy and water access might generate inherent trade-offs for individuals or land-use sectors. This happens when land is prioritized for delivering a particular service or services bundle or is needed to connect one or several services with the consumers, thus excluding or constraining other priorities (Tallis and Polasky 2009; Sandström et al. 2011).

Socio-economic instruments, such as payments for ES, indirect economic benefits through market instruments (ecolabels, certificates) or governmental funding programs as implemented, for instance, in the second pillar of the EU Common Agricultural Policy (CAP), are discussed as being

appropriate to alleviate inequalities or discrimination of land owners (Kroeger and Casey 2007; Farley and Costanza 2010; Van Zanten et al. 2014). Their efficiency, however, in fully compensating restrictions toward affected land owners and in increasing sustainably the supply of desired services can be questioned and thus requires institutional embedding in the particular social-ecological context (Vatn 2010; Schomers and Matzdorf 2013).

### 3. Achieving coherence between management, planning and policy-making across sectors and scales

The described ES nexus could provide a common ground for connecting policies, spatial planning and land use by means of their specific instruments and action types. Figure 2 summarizes how they are connected through instruments such as impact assessment or market mechanisms (*outer circle*) and which concrete measures they can use to impact ES supply capacities (*inner circle*).

In Europe, for instance, policies proposed by different sectors within the European Commission, such as agriculture, forestry, climate, environment etc., undergo a formal policy impact assessment prior to their approval. Through this assessment, the social, ecological and economic implications of possible scenarios associated with the concerned policy are analyzed and used to support policy-making (see e.g. Helming et al. 2011). As an example, the Strategic Environmental Assessment (SEA) has been adopted by many countries around the world to help protect the environment and promote sustainability, by ensuring that environmental considerations inform the development and approval of policies, plans and programs. The content of SEA often goes beyond environmental issues to include also other concerns associated to human well-being, such as health, equity and social inclusion. For these reasons, SEA is a suitable tool to integrate ES in decision-making processes, so as to improve the understanding of the unattended and unintended consequences of strategic decisions on human well-being (Kumar et al. 2013; Geneletti 2016). There is a growing interest in the potential of SEA to mainstream ES concerns in decision-making, as shown by recent scientific publications (Geneletti 2013, 2015; Karjalainen et al. 2013; Rozas-Vasquez et al. 2017) and reviews of practices (Rosa and Sanchez, 2015). Implementing ES in SEA and policy impact assessment would help to improve insights into scale impacts and consideration of environmental benefits and values (Diehl et al. 2016). Accordingly, consideration of ES in project-level Environmental Impact Assessment (EIA) would improve the transparency of the assessment results

and of potential compensation measures considering particularly the impacts of land consumption by the built environment and technical infrastructure (Latimer 2009; Villaroya and Puig, 2013). The use of an ES approach in impact assessment offers also the advantage of presenting a more holistic and integrated consideration of the socio-ecological system, and a framing of environmental issues that appear to be more effective in terms of engaging and influencing stakeholders and decision makers (Baker et al. 2013). Furthermore, the explicit reference to ES in EIA could contribute to ensure that the provision of key natural resources is more prominently incorporated in environmentally relevant projects. This would be of particular importance in developing and newly industrialized countries, where investment projects might cause highly negative trade-offs for food and water security creating serious societal conflicts (see e.g. Grumbine et al. 2012).

At the interface between policies and land-use practice, governmental instruments might face some limitations to ensure that the principles of democracy are respected. Here, market mechanisms such as forest certification or eco-labeling are appropriate governance mechanisms for establishing coherence between policy and societal goals on the one hand, and interests of the land owners on the other (Bachev, 2009). They could add particularly to the sustaining and enhancing of regulating services beyond those incorporated in current cross compliance requirements (Koellner 2011). If conceived in a smart manner, market mechanisms could add to strengthening the necessary collaboration between different land-use actors so that synergy effects from harmonized land-use practices would arise as formulated, for instance, as one of the key policy objectives of the CAP reform toward 2020 (EC, 2011).

Considering implementation measures at policy level, funding schemes including direct or indirect payments as implemented, for instance, in the two CAP pillars address both the adjustment of appropriate management intensities in land use and the development of ecological (green) infrastructures as an interface to spatial planning (Hodge et al. 2015). This might however result in conflicting trade-offs for the different ES groups: while regulating and cultural services are enhanced by cross-compliance and greening regulations, provisioning services can be decreased (Hauck et al. 2014).

Legal constraints, such as protecting habitats and ecologically valuable areas (e.g. Habitat Directive 92/43/EEC) or distance regulations to water bodies (e.g. Water Framework Directive 2000/60/EC), urge spatial planning to consider EU biodiversity and ES targets. Spatial planning implements such legal regulations by identifying

and delineating prior areas either for given 'functions' (flood protection, drinking water provision) or for specific land uses (Larsson 2006). A paradigm shift toward the delineation of services providing and connecting areas would innovate spatial planning toward a more integrative style of developing land-use patterns with enhanced potentials for ES provision and would thus provide policy makers, planners and land managers with improved common grounds for decision-making (Crossman et al. 2013).

#### 4. Appraisal of the nexus approach

The question how to best implement ES in policy-making and planning resulted in manifold publications that have provided sound arguments for why the perception of ES in spatial and land-use planning practice is low and why implementation still fails. Reasons can be found, among others, in the lack of sound scientific concepts (Daily et al. 2009; Opdam 2013) and insufficient involvement of actors and their decision-making practices (Cowling et al. 2008; Slootweg 2016) in shaping the ES concept. On the other hand, many practical examples already exist for the successful implementation of ES particularly as a means to co-produce knowledge and build consensus in participatory planning (Albert et al. 2014). However, there is still a need to develop criteria that could help to decide on which planning context or which phase of a decision-making process the use of ES provides the greatest benefits (Fürst et al. 2014).

Our hypothesis was that ES contribute considerably to increase the coherence between environmentally relevant policy sectors, spatial planning and land use when they are based on the nexus among people, nature and the scales where these interact. We argue that the success in implementing ES depends on their strategic and consistent introduction in all instruments and measures through which policy, spatial and land-use planning processes interact. So far, these interactions are not adequately taken into account in ES studies so that the benefits of using the ES concept compared to others, such as sustainability or multifunctionality, are not yet transparent for actors from practice. Consequently, the potential of the ES concept to contribute to achieving the UN Sustainable Development Goals throughout all levels of decision-making has not been fully exploited since MEA (2005) was published. Here, the ES nexus could form an integrative umbrella that contributes to make synergetic use of the very similar concepts, theories and methods behind ES, sustainability and multifunctionality (Huang et al. 2015).

Recent top-down processes such as IPBES and the EU Biodiversity Strategy, which put political pressure

on using ES as a reference for assessing sustainability, run the risk of failing to engage actors in planning and land management practice, even though stakeholder processes and integration of local and indigenous knowledge are an integral part of them (see e.g. Turnhout et al. 2012). A strength of our suggested ES nexus approach consists in revealing trade-offs between ES groups, across scales and among the different intervention opportunities and implementation measures of policy-making, spatial and land-use planning. Nexus thinking could support ex-ante assessments of prospected changes in policies, plans and projects looking at response mechanisms in a manner that enables the mutual co-adaptation of corresponding instruments and intervention alternatives. As an example, spatial plans at the national or NUTS III/II level could be much better harmonized with (structural) funding programs for regional and rural development such as EFRD (European Fund for Regional Development) or EAFRD (European Agricultural Fund for Rural Development) and thus contribute to territorial cohesion as one of the key EU policy objectives (Crescenzi et al. 2015).

Still, a problem consists in the missing integration of different environmentally relevant policy sectors (Jordan and Lenschow 2010). Even if single policy sectors incorporate and adapt their funding policies and legal operationalization within the nexus, there are still conflicts between them particularly when it comes to the 'right' implementation measures (Nilsson et al. 2012). Prominent examples of the lack of coherence between policy sectors are the increasing conflicts in target setting and implementation between bioenergy, climate and biodiversity policies (Makkonen et al., 2015; Söderberg and Eckerberg 2013). The ES nexus could help to detect how missing coordination between the policy sectors endangers sustainable development through competing objectives in land use and to identify solutions for how to achieve balance between them without jeopardizing the ES and resource needs of future generations.

## 5. Conclusions and outlook

We presume that the ES concept and its scientific foundation have been developed well enough to be deployed in practice. The next step deciding upon the success or failure of the ES concept will be its consistent use in pre-assessing and co-developing policy, spatial and land-use planning instruments. Recent studies reveal already the importance and applicability of ES concepts in impact assessments on various scales and as valid references for shaping market mechanisms in support of improved consideration of biodiversity in tandem with nature conservation goals and overall human well-being (Geneletti 2011; Baker et al. 2013; Helming et al. 2013; Muradian

and Gómez-Baggethun 2013; Howe et al. 2014; Iniesta-Arandia et al. 2014).

ES could be introduced successfully to increase the coherence among different decisional scales by referring to a nexus approach, which aims particularly at revealing the interactions between humans and nature, and between policy sectors, spatial planning and land use. Embedded in this nexus, ES could help to facilitate the identification of synergies and potential conflicts between different policy sectors and help to harmonize particularly their implementation measures so that no competing signals are sent out to spatial planning and land management. They could also contribute to widen the decision-making space of land-use sectors and their actors by supporting trade-off analyses and identifying substitutional strategies in land management while shaping landscape patterns.

Scale effects are crucial for the perception of how relevant particular ES are and how well the supply and demand are balanced within a regional and global context. Here, nexus thinking would support a world-wide ranging development of social-ecological systems, recognizing their economic, cultural and ecological particularities and their value for inter- and intra-generational equity in the access to natural resources.

Still, research exploring the use of ES to facilitate transboundary resource governances remains scarce. Hence, the ES nexus could facilitate consensus-building processes in biodiversity conservation, infrastructural development or in joint efforts to harmonize economic growth without threatening ecological processes. Recent approaches for enhancing the use of local and indigenous knowledge through e.g. crowd-sourced information, swarm intelligence at open-access platforms or other social-media would be a highly valuable supplement to ensure a broad use and acceptance of ES, while at the same time obtaining relevant information on land-use practices, value systems and adaptation opportunities as key inputs for the ES nexus.

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## Disclosure statement

In accordance with Taylor & Francis policy and our ethical obligation as researchers, we are reporting that we have no

conflicting interests that may be affected by the research reported in the enclosed paper. We have disclosed these interests fully to Taylor & Francis, and we have in place an approved plan for managing any potential conflicts arising from such involvement.

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