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Sustainability impact assessment of peatland-use scenarios: Confronting land use supply with demand

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A B S T R A C T

Sustainable development of land use is determined by changes of the regional supply of Land Use Functions (LUFs) and the demand of future societal land use claims. LUFs are based on the ecosystem services concept, but more adapted to human land use. In this paper, we assessed two peatland-use scenarios towards sustainable development in Northeast Germany in order to understand their impacts on LUFs and land use claims. For this, we extended an analytical framework designed to confront LUFs with land use claims identified in multi-level stakeholder strategies in a participatory manner. The sustainability assessment was performed with peatland-use scenarios *"Services for services"* and *"Market determines usage"* that favoured environmental and economic land use claims, respectively. Findings revealed possible trade-offs between land use claims for biomass production and regional value creation as well as for peatlands` carbon and nutrient sink, and habitat functions. The core achievement is an extended sustainability assessment framework integrating land use demands of multi-level stakeholder strategies into participatory impact assessment, in a way that land use claims serve as benchmarks for LUFs. This facilitates the understanding of sustainable land use in both supply and demand perspective, and the normative evaluation of ecosystem services.

1. Introduction

Land use changes affect sustainable development (SD) through a set of multi-level, trans-sectoral and cross-policy issues (Söderberg and Eckerberg, 2013; Jordan and Lenschow, 2010; Helming et al., 2008). Land use drivers, including European policies such as the Common Agricultural Policy (CAP; van Zanten et al., 2013); national policies such as the German renewable energy law (*Erneuerbaren Energien Gesetz;* EEG), globalization (Burkhard et al., 2016) and urbanization lead to land use changes in rural and semi-rural areas in Europe. The supply of ecosystem services, and public goods and services provided by multifunctional land use (Schößer et al., 2010) is affected by these policies` tendencies to focus on monofunctional, large-scaled managed agricultural landscapes (Burkhard et al., 2016). Some drivers, such as the 2nd pillar CAP measures, can as well support multifunctional land use systems (Butterfield et al., 2016; Wilson, 2007). In addition, at the regional level, land use is affected by diverse societal targets (e.g., water protection or securing employment in rural areas) that lead to land competition for different purposes (Germer et al., 2011; Harvey and Pilgrim, 2011). Thus, land use changes are always connected with trade-offs regarding multiple societal targets and with intended and un-intended impacts (Wiggering et al., 2006). To assess the impacts of land use changes, manage trade-offs, and develop strategies for sustainable land use, the linkage with the normative concept of SD (Kopfmüller et al., 2001) and integrative and spatially explicit approaches are required (Helming et al., 2011a; Pérez-Soba et al., 2008). These approaches need to interlink endogenous (biogeophysical, socio-cultural and socio-economic conditions) with exogenous (normative values and societal land use demands) factors (Helming et al., 2011a). In this article, we demonstrate such an integrative and spatially explicit approach to assess the impacts of land use changes on SD.

We considered SD of land use as the ability to fulfil an integrated set of societal targets for the dimensions environment, economy and society (Pope et al., 2004; Hansen, 1996). It could be an instrument

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for governments, companies and societal actors with diverging stakeholder targets and normative values, particularly with respect to the importance of the SD dimensions (Lange et al., 2015). But, the operationalization of SD of land use is challenged by the lack of decision-relevant and operationally functioning assessment methods (Pintér et al., 2012; Rounsevell et al., 2012; De Groot et al., 2010; Turner and Daily, 2008; Hacking and Guthrie, 2006; Wiggering et al., 2006). The development and application of such assessment methods is challenged by (i) moving policy targets and the introduction of new policy fields and sustainability indicators (Petit and Frederiksen, 2011), (ii) the complex interrelations and trade-offs between SD dimensions (Pintér et al., 2012; World Commission on Environment and Development (WCED), 1987), (iii) the need for integration of quantitative and qualitative information (Hacking and Guthrie, 2008), (iv) the definition of causal linkages between human and natural interactions (Rounsevell et al., 2012), (v) the link between ecosystem service provision and land use related functions and services with stakeholder preferences, i.e., normative values and societal land use demands (Burkhard et al., 2016; Larondelle and Lauf, 2016; Rametsteiner et al., 2011; Müller and Burkhard, 2007), (vi) the consideration of manifold stakeholder preferences at various governance levels (Cook et al., 2016; Hacking and Guthrie, 2006), and (vii) the participation of stakeholders in the assessment steps (Spangenberg et al., 2015; König et al., 2015; Pintér et al., 2012).

Using an integrative and spatially explicit *ex-ante* Sustainability Impact Assessment (SIA; Helming et al., 2008) of the expected effects of land use changes in specific research sites, this current case study investigated impacts of land use changes to peatlands in Northeast Germany on SD and human well-being. In terms of the *ex-ante* SIA of land use scenarios, it is essential to confront the future region-specific supply of Land Use Functions (LUFs) with societal land use demands (Hermanns et al., 2015; Paracchini et al., 2011; Helming et al., 2011a, 2011b; Pérez-Soba et al., 2008). LUFs are based on the concepts of ecosystem services and land use multifunctionality; they can be used as a practical approach to operationalize stakeholders` preferences for land use. Compared to ecosystem services the LUF concept is more adapted to the human use of the land and more strongly takes account of socio-economic aspects. Schößer et al. (2010) provided a comprehensive analysis of the interrelations between the two concepts. LUFs also conceptualise the services of the land for human wellbeing and are sensitive to the way the land is used, but not necessarily to underlying ecosystem functions. Other than ecosystem services they include services derived from land sealing such as for infrastructure and housing as well as second order services from value chain creation of biomass production. Likewise to the ecosystem services concept, implementing the LUF concept into *ex-ante* SIA has the potential to improve the accountability of spatial planning (Geneletti, 2011). To determine the impacts of land use scenarios on LUFs, Helming et al. (2011a) developed an analytical framework for sustainability assessment of policies affecting the regional supply of LUFs. For the implementation of the analytical framework quantitative and qualitative methods are developed (Helming et al., 2011b). The Framework of Participatory Impact Assessment (FoPIA) employs a qualitative and participatory approach to relate *ex-ante* impact assessments with SD. The FoPIA approach was first described by Morris et al. (2011), who link the expected effects of land use scenarios with the normative preferences of stakeholders by evaluating those perceived scenarios' impacts on LUFs.

Participatory methods identify the normative values and demands of stakeholders related to ecosystem functions and services provided by land use (Palacios-Agundez et al., 2014; Reed et al., 2009). Ollson et al. (2009) developed a goal-oriented indicator framework to support integrative policy assessments of agri-environmental systems. Integrative and science-based approaches are also used to operationalize SD into sustainability rules and assess land use scenarios (Kopfmüller et al., 2001; Grunwald and Rösch, 2011). Pope et al. (2004) and Hacking and Guthrie (2006) highlight the need for an objectives-led impact assessment to achieve a particular vision or outcome defined by integrated environmental, social and economic objectives. Such objectives-led SIA approaches to policies and plans have some advantages. First, they avoid inherent limitations (e.g., trade-offs between the SD dimensions or a lack of direction), unlike approaches that are exclusively oriented towards the triple bottom-line (Pope et al., 2004). Second, they simplify communication with stakeholders and decision-makers about how to achieve policy targets and minimize trade-offs in land use (Ollson et al., 2009).

Hermanns et al. (2015) extended the analytical framework of Helming et al. (2011a). It can specify the supply portfolio of LUFs into sustainability-relevant topics and identify demand portfolios of land use claims within multi-level stakeholder strategies as well. In this way, an objectives-led SIA approach for land use scenarios affecting LUFs was designed. However, knowledge gaps related to the *ex-ante* SIA of land use scenarios at the regional level remain. These gaps include: (i) an analytical framework that links a participatory assessment of the impacts of land use scenarios on the supply of LUFs with the societal demand of land use claims is lacking; and (ii) there is no linkage of identified land use claims as benchmarks for the supply of LUFs. Hence, we extended the analytical framework of Hermanns et al. (2015) for participatory application jointly involving researchers and stakeholders in a case study on *ex-ante* SIA of peatland-use scenarios. To confront the changes of a supply portfolio of LUFs with a demand portfolio of societal land use claims, we adapted the FoPIA approach of Morris et al. (2011). We used findings from Hermanns et al. (2015) for this current case study. The objective of this paper is to apply the analytical framework for the *ex-ante* SIA of peatland-use scenarios and to confront the region-specific supply of LUFs with the corresponding demand of land use claims. The subgoals included: (i) to select sustainability-relevant topics and indicators in a joint approach of co-production with researchers and stakeholders; (ii) to select land use claims as normative benchmarks for the supply of LUFs; and (iii) to assess the impacts of peatland-use scenarios in a participatory assessment workshop.

2. Materials and methods

2.1. Case study

Our research was part of an interdisciplinary research project (development of integrated land management for sustainable land and matter utilization in Northeast Germany; ELaN), which examined land management and governance strategies for sustainable land use in Northeast Germany. Strategies included wastewater utilization in the surrounding of Berlin and alternative peatland-use systems in the federal state of Brandenburg. Here, we focused on peatlands-use systems, for which land use scenarios were developed. At present, Northeast Germany's peatlands are often drained and cultivated for agricultural production with either intensive or extensive grassland. As a consequence the region's groundwater level is decreasing. Under conditions of climate change, this decreasing groundwater level implies increasing conflicts among stakeholders' SD targets, mainly because drying wetlands are understood to lead to decreased biodiversity as well as decreased grassland and forest productivity (Schwand and Steinhardt, 2016; Germer et al., 2011). In addition, drained peatland is a source of carbon thereby reinforcing driving forces for climate changes. Likewise, peatland is understood to be an important target area for climate change mitigation action because of its potential for carbon sequestration (Jarveoja et al., 2016). The biogeophysical conditions of these peripheral rural areas can be characterized as providing marginal agricultural revenues but high-quality habitats and important sink functions for water and matter fluxes as well as carbon sequestration in a near-natural state (Schwand and Steinhardt, 2016). As research site, the peatland areas in the *"Randow-Niederung"* in the county of *Uckermark* in the federal state of Brandenburg were explored in this case study. For a detailed map of the explored peatland areas see Fig. 1.