Developing stakeholder-driven scenarios on land sharing and land sparing – insights from five European case studies

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Highlights

- Hierarchical scenario approach to integrate multi-scale drivers and local context
- Quantitative scenarios suitable for ecosystem service and biodiversity assessment
- Scenarios implement land sharing and land sparing strategies in European regions
- Results are standardized, comparable case study-specific land use scenarios

Abstract

Empirical research on land sharing and land sparing has been criticized because preferences of local stakeholders, socio-economic aspects, a bundle of ecosystem services and the local context were only rarely integrated. Using storylines and scenarios is a common approach to include land use drivers and local contexts or to cope with the uncertainties of future developments. The objective of the presented research is to develop comparable participatory regional land use scenarios for the year 2030 reflecting land sharing, land sparing and more intermediate developments across five different European landscapes (Austria, Germany, Switzerland, The Netherlands and Spain). In order to ensure methodological consistency among the five case studies, a hierarchical multi-scale scenario approach was developed, which consisted of i) the selection of a common global storyline to frame a common sphere of uncertainty for all case studies, ii) the definition of three contrasting qualitative European storylines (representing developments for land sharing, land sparing and a balanced storyline), and iii) the development of three explorative case study-specific land use scenarios with regional stakeholders in workshops. Land use transition rules defined by stakeholders were used to generate three different spatially-explicit scenarios for each case study by means of high-resolution land use maps. All scenarios incorporated various aspects of land use and management to allow subsequent quantification of multiple ecosystem services and biodiversity indicators. The comparison of the final scenarios showed both common as well as diverging trends among the case studies. For instance, stakeholders identified further possibilities to intensify land management in all case studies in the land sparing scenario. In addition, in most case studies stakeholders agreed on the most preferred scenario, i.e. either land sharing or balanced, and the most likely one, i.e. balanced. However, they expressed some skepticism regarding the general plausibility of land sparing in a European context. It can be concluded that stakeholder perceptions and the local context can be integrated in land sharing and land sparing contexts subject to particular process design principles.

Keywords

- participatory land use scenarios
- multi-scale scenarios
- sustainable land use
- stakeholder engagement
- co-production

1. Introduction

Land use and management largely determine agricultural yields as one of several provisioning ecosystem services (ES), but also fundamentally influence regulating and maintenance services (e.g. water purification, soil retention or climate regulation) as well as cultural services (e.g. pleasant landscapes) (Duru et al., 2015; Power, 2010). These other ES have declined as a result of changes in land use and management towards enhanced food production on a global level (Millenium Ecosystem Assessment, 2005; Rasmussen et al., 2018), thereby increasing the vulnerability of ecosystems (Power, 2010; Schröter et al., 2005). Such developments reveal the trade-offs between provisioning ES (i.e. food, fiber), regulating and maintenance ES, and cultural ES (Kanter et al., 2016; Lee and Lautenbach, 2016; Maes et al., 2012; Power, 2010). Besides driving the decline of non-provisioning ES, intensification of agricultural production poses severe threats to global biodiversity as well (Duru et al., 2015; Harrison et al., 2014; Isbell et al., 2015; Maes et al., 2012).

Hence, two contrasting concepts have been proposed to reconcile land use conflicts and to minimize trade-offs between food production (provisioning ES) and biodiversity: Land sharing (LSH) and land sparing (LSP). LSH is wildlife-friendly farming aimed to ensure the coexistence of agricultural production and nature conservation, e.g. extensively managed cropland with landscape elements within the plot, such as flower strips (Balmford et al., 2005; Green et al., 2005; Phalan et al., 2011a; Phalan, 2018). In LSP, on the contrary, land for nature conservation is strictly separated ("set aside") from agricultural land. Therefore, in particular fertile agricultural land with high yield potential shall be used as intensively as possible in order to reduce conversion pressures on natural land or to release marginal agricultural land for nature conservation (e.g. rewilding, see Navarro and Pereira, 2012). Both concepts have been studied theoretically (e.g. Balmford et al., 2005, 2015; Fischer et al., 2008, 2014; Green et al., 2005; Phalan et al., 2011a; Phalan, 2018 or Tscharntke et al. 2012a, 2012b) and empirically (e.g. Chandler et al., 2013; Edwards et al., 2013; Hulme et al., 2013; Macchi et al., 2013; Navarro and Pereira, 2012; Phalan et al., 2011b or Law et al. 2015). Overall, research on LSH/LSP is driven by ecological perspectives on landscapes and from a biodiversity conservation viewpoint (Luskin et al., 2017). The empirical LSH/LSP studies focus on the Global South (Luskin et al., 2017), but there are some examples for the northern hemisphere as well, mainly in the US and UK (e.g. Gabriel et al., 2013; Hodgson et al., 2010; Quinn et al., 2012 or Egan and Mortensen 2012). The diversity of agricultural landscapes in Europe, however, calls for a multi-regional, standardized case study-based approach.

Besides the regional context, the spatial extent of a case study is of key importance for ES and biodiversity assessments as trade-offs are often scale-dependent (Cord et al., 2017; Lindborg et al., 2017). Most empirical studies assess LSH and LSP effects either on a field or a landscape scale with the latter being increasingly favored (Sayer et al. 2013; Fischer et al. 2017; Tscharntke et al. 2005; Cordingley et al. 2015). In fact, a multi-scale perspective is needed, as land use history, local values and preferences, soil characteristics and climate influence land use at the local scale (Fischer et al., 2014; von Wehrden et al., 2014). Other socio-economic factors (e.g. employment opportunities) influence land use at the regional scale and external drivers such as agricultural policies (e.g. the EU Common Agricultural Policy), trade treaties or climate agreements (e.g. the Paris agreement) are defined at national to continental scales. Such drivers of land use are typically not considered in many applied LSH/LSP studies (Fischer et al., 2017a, 2014; Godfray, 2011; Grau et al., 2013; Ramankutty and Rhemtulla, 2013).

In ex-ante land use studies including ES assessments, "a common strategy for maintaining the internal consistency of driving forces is to first develop storylines (…) that provide a logic for the many different assumptions about future changes in population and other drivers" (Alcamo et al., 2006, p. 138). Storylines describe alternative future states of drivers – frequently for larger spatial and administrative units than the research area – in a qualitative way. They are helpful in participatory scenario processes with multiple regional case studies to frame the definition of detailed region-specific quantitative, spatially-explicit land use scenarios (e.g. Kok et al., 2006). Such a multi-scale approach has been widely applied in land use studies (e.g. Booth et al., 2016; Carpenter et al., 2015; Lamarque et al., 2013; Lindborg et al., 2009; Malek and Boerboom, 2015; Rounsevell et al., 2006; Swetnam et al., 2011 and Martinez-Harms et al., 2017). For instance, Swetnam et al. (2011) presented a GIS-based method to transform qualitative storylines about socio-economic trends in the Easter Arc Mountain chain in Tanzania to quantitative map-based scenarios, integrating local stakeholders and experts and formalizing spatially-explicit rules. Their approach is adapted to a specific case study design but not suitable for a range of land use contexts and for achieving comparability among case studies. Indeed, most existing land use scenario studies focus on single case studies, e.g. as in scenario exercises by Lamarque et al. (2013), Booth et al. (2016) or Carpenter et al. (2015). Apparently, comparability among case studies requires an adapted research design.

So far published LSH/LSP studies have rarely adopted multi-scale scenario approaches. For example, Law et al. (2015) and Mastrangelo and Laterra (2015) used scenarios but did not follow a multi-scale approach, where scenarios are linked with storylines, i.e. with the development of particular land use drivers. Verkerk et al. (2018) followed a normative scenario approach. They developed three different stakeholder-based land use visions for the EU with varying levels of multifunctionality (e.g. LSH). They then identified pathways to realize these visions linking several land use simulation models, instead of analyzing the impacts of the single land use scenarios as typically done in ES and land use research (i.e. as in an explorative approach).

Stakeholders have been yet rarely integrated into LSH/LSP studies, and this has been heavily criticized by e.g. Fischer et al. (2014) and Scariot (2013). One of the criticisms is that possible outcomes of research endeavors influence the regional provision of ES and biodiversity and consequently determine the wellbeing of the local population (Fischer et al., 2017a). Furthermore, local land managers have to be convinced to change management practices, which is more likely in a participatory process. Stakeholders' demands on LSH/LSP are likely heterogeneous within the local society and are potentially different from the demands of the society outside the region. Hence, the type and regional distribution of ES seem decisive for an agreement among stakeholders and preferences of land use strategies (Fischer et al., 2017a). For farmers, for example, the provisioning service potential may be specifically important, but a tourist might have a stronger preference for conserving landscapes and biodiversity (Manning et al., 2018). Furthermore, it is unclear how stakeholders perceive these two land use strategies particularly with respect to the political claim of multifunctionality in some European landscapes (Fischer et al., 2017b).

To tackle the revealed challenges, especially the shortcomings of previous LSH/LSP studies, regional case study-specific scenarios were developed for LSH, LSP and a balanced land use (LBA) that shall cover an intermediate state of land use within the LSH/LSP continuum. Five regions were selected within Europe with contrasting but representative agricultural landscapes. Using regional case studies allows to integrate local stakeholders' knowledge, as well as high-resolution socio-economic (e.g. farm structure) and bio-physical (e.g. soil) data. At the same time, comparability of case study-specific scenarios shall be ensured by developing them through a standardized definition process with common scenario elements (see Zurek and Henrichs, 2007). Developing multiple, comparable case studies increases the spatial extent of research under heterogeneous framework conditions.

This research is part of the project TALE ("Towards multifunctional agricultural landscapes in Europe: Assessing and governing synergies between food production, biodiversity, and ecosystem services"), funded within the framework of BiodivERsA/FACCE-JPI. TALE aims at disentangling and quantifying the multifaceted links between agricultural production, biodiversity and other ES in different European landscapes. In a later stage, these scenarios will be used to support a comparable assessment of ES and biodiversity trade-offs across scenarios and case studies. The following research questions are addressed in this article:

- How can LSH/LSP be operationalized in a regional context (vs. global context)?
- How can qualitative and quantitative land use information from stakeholders be consistently transformed into quantitative spatially-explicit information?
- What are plausible regional land use outcomes of LSH/LSP and more balanced scenarios which are also suitable for ES and biodiversity assessments?
- What is the role of the case study context when defining stakeholder-based scenarios of LSH/LSP?

2. Data and methods

Five case study regions were selected for developing the land use scenarios. Analyzing contrasting (e.g. different socio-economic contexts) but representative regions with respect to land use and ES broadens the spatial extent and scope of the assessment. The chosen case study size enables a high spatial resolution within the individual regions. The case study regions are described in section 2.1, important land use drivers in 2.2 and the hierarchical multi-scale scenario approach in 2.3.

2.1. Description of the case study regions

The case study regions are diverse with respect to size, climatic conditions, land use, ES and biodiversity but all belong to what can be considered a regional scale. The German Middle Mulde river basin (GER) has a size of 1,624 km², the Broye catchment in Switzerland (CH) of 635 km² and the Mostviertel in Austria (AT) of 3,359 km². All three regions are in the Continental environmental zone according to Metzger et al. (2005). The Kromme Rijn in the Netherlands (NL) has a size of 219 km² in the Atlantic Central zone. The Cega-Eresma Adaja basin in Spain (ESP) is 7,854 km² large and in the zones Mediterranean North/Mediterranean Mountains. While the case study regions in GER, CH and ESP are dominated by cropland, the regions in AT and NL are dominated by permanent grassland (and forest in AT).

Nutrient loads and water quality problems have been identified as the most widespread environmental issues in the case study regions by stakeholders, with intensification of agriculture being the main cause of the problem (van der Zanden et al., 2016). In AT, the loss of permanent grassland and landscape elements has been highlighted (Schönhart et al., 2011). Soil degradation and water quantity problems are also of importance in all case studies, except for NL. Marginalization is an issue in AT and ESP. Climate change is expected to negatively affect productivity as well as the environment (e.g. via increased erosion) in GER, CH and ESP. In AT, an increase of productivity can be expected for the coming decades. Unique to ESP is the threat of groundwater overexploitation due to the prevailing high irrigation intensity. Soil sealing is important to GER and CH. Main land cover classes of all case studies are presented in Figure 3, main crops in Figure 4 and management related data in Table 2. Additional details for each case study are provided by Appendix A.

2.2. Important land use drivers and relevant policies

A number of factors drive land use change and its effects on biodiversity and ES in the case study regions. Structural changes in agriculture (e.g. agricultural policies and subsidy regimes) and productivity growth are among the most important drivers (van der Zanden et al., 2016). The EU Common Agricultural Policy and analogous policies in Switzerland directly influence agricultural land use and land management with direct payments including a greening component, agri-environment-climate measures, support of organic farming and payments for disadvantaged areas (Nitsch et al., 2017). Regulatory instruments influence land use in all case studies, namely restrictions regarding fertilizer use, water protection and biodiversity conservation. Nitsch et al. (2017) also identified information and extension services as supporting measures for steering the management of agricultural land. This is for instance of prime importance in ESP, where the regional technological agrarian institute (ITACYL, in Spanish) provides farmers with tools and real-time information to adapt irrigation requirements and other farming practices. Many of the named policy instruments are influenced or even governed by national or EU regulation. Nevertheless, where there is scope for countries or regions to adapt or design individual measures, they may also reflect traditions and historical developments in the respective case study regions. For example, planning policies and cooperative approaches are outstanding and have a long history in the Netherlands. Result-oriented measures for biodiversity conservation have a long tradition in Switzerland and are only gradually introduced in other countries. In addition to agricultural policies, consequences of climate change and increasing water demand have been rated as most important drivers for land use change in CH, the latter being also a major issue in ESP.

2.3. Hierarchical multi-scale approach of land use scenario development

The assessment and comparison of case study results needs a standardized scenario definition process. Comparability among the land use scenarios, in turn, requires equal underlying political trends on a common scale such as Europe and common scenario elements (Zurek and Henrichs, 2007). In the following, a multi-scale approach is presented, which is designed to ensure these aspects and is applied to the case studies.

2.3.1. Process overview

A participatory hierarchical multi-scale scenario approach is applied (Figure 1). Hierarchical relates to the fact that "the more aggregated level can be seen to set the boundary conditions for any lower level of aggregation" (Zurek and Henrichs, 2007, p. 1283). This approach broadens the spatial extent of preceding studies through assessing multiple, contrasting case study regions across Europe and maintains a high spatial resolution for subsequent ES and biodiversity assessments. The hierarchical multi-scale approach consists of: i) selection of a global storyline, ii) definition of three European storylines, which are in accordance with the global storyline, and iii) development of three explorative, case study-specific land use scenarios aligned to the storylines. This approach allows the consideration of both common global and European land use drivers and case study-specific developments. Hence, it enables both standardization of the scenario approach and comparability among the case studies.

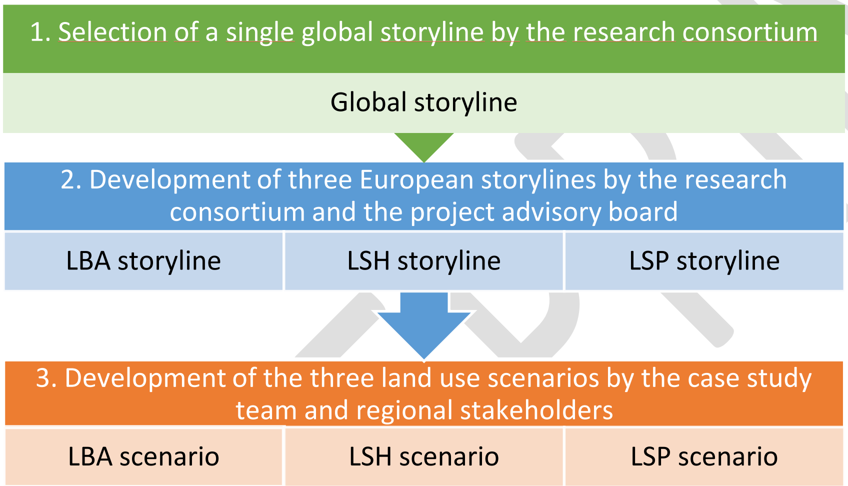

Figure 1: Overview of the hierarchical multi-scale scenario approach and groups involved in the development of storylines and scenarios (LBA = balanced land use, LSH = land sharing, LSP = land sparing)

2.3.2. Storyline development

The choice of a single global storyline shall reduce complexity for the subsequent stakeholder process. By choosing an existing storyline, connectivity to the scientific literature shall be ensured. Hence, the well-established Shared Socio-Economic Pathway "Middle of the Road" storyline (SSP2) (O'Neill et al., 2015) is selected as the global storyline, which appears broad enough to cover both LSH and LSP drivers. SSP2 describes moderate socio-economic challenges for climate change mitigation and adaptation. Generally, SSP2 represents social, economic and technological development trends which follow historic patterns (O'Neill et al., 2015). In this approach, the global storyline framed the subsequent definition of European storylines by the researchers and the advisory board of national and European experts - a consecutive scenario process according to Zurek and Henrichs (2007). The storylines share some scenario elements with the global storyline but are more detailed with respect to the contrasting developments of agricultural input and output prices, direct payment funding, greening requirements, agri-environmental program (AEP) funding, environmental and nature protection legislation, EU food consumption and other aspects until 2030.

Each storyline describes framework conditions to foster a LSH, LSP or balanced (LBA) land use situation (Figure 2). LBA represents a trend scenario as well, since no major policy changes are assumed here and stakeholders have classified all case study regions as rather balanced at the moment, as shown in Figure 2. Hagemann et al. (2018) present more details on the storyline development and stakeholder process.

2.3.3. Spatially-explicit scenario development with stakeholders

Several methods are suggested for participatory scenario development such as interviews or focus groups, stakeholder panel workshops, gaming workshops, policy exercises or story and simulation approaches (Alcamo et al., 2006). However, multi-scale approaches require methods that facilitate consistency among the hierarchical levels and enable the transfer of qualitative scenario data to quantitative parameters. Mallampalli et al. (2016) review translation methods to transfer qualitative storylines to spatially-explicit quantitative scenarios. They criticize that translations were too often left to technical modelers, although the integration of stakeholders allows gaining new insights for both groups, scientists and stakeholders, and thus enriches scenario definition. Moreover, the reviewed translation methods are appropriately applied only when experts and stakeholders collaborate.

In this study, spatially-explicit explorative land use scenarios were developed with regional stakeholders in one to two workshops in 2016 and 2017 in each case study region. Stakeholders were selected based on their expertise on resource management, agriculture, administration and regional planning and included farmers, foresters, members of environmental/nature protection NGOs, tourism experts, policy or decision makers at the local to regional level, teachers and administration employees. Joint stakeholder guidelines supported the stakeholder process and ensured that people from all relevant sectors were invited. Nevertheless, the number of workshop participants varied across case studies from five to 24 (see Appendix B for more details on the participating stakeholders). After the first scenario workshop, each case study team interacted with the participants via e-mail or personally through a second workshop to validate and finalize the scenarios. Another round of stakeholder workshops was held in all case studies in 2018, during which the developed spatially-explicit scenarios and quantitative results of the ES and biodiversity assessments and models were discussed.

To ensure comparability, the scenario definition process in each case study followed a standardized protocol (see Appendix C) in a parallel scenario process (Zurek and Henrichs, 2007), i.e. different groups of people developed scenarios according to common framework conditions (i.e. the European storylines). The different scenarios in and among case study regions are linked through common scenario elements (see Table 1). The protocol includes the methods of interaction with stakeholders and a set of minimum scenario parameters (Table 1) (e.g. specifications of land use categories, farm structure and agricultural policies). In each case study, the scenario timeline refers to 2030. In addition, each case study team defined the level of details on scenario parameters for case study-specific modelling of ES and biodiversity.

Table 1: Minimum scenario parameters covered in all case study-specific scenarios

Class	Unit(s)	Parameters
Land use	% of total land or km^2	Built-up area, cropland, other arable land, plantations and orchards, permanent grassland, other natural land, forest, high nature value farmland, protected area, ecological focus areas
Land management	% of current land use or mass/ha or volume/ha	Fertilization intensity cropland, fertilization intensity grassland, irrigated area, irrigation intensity, fertilization options, pesticide management, cover crops, organic farming, mowing frequency
Crops	% of cropland	Winter grains, maize, other grains, temporary grassland, other crops
Soil management	% of cropland	Ploughing, minimum tillage
Livestock	Units per ha	Livestock density

For the workshop, each case study team delineated the storylines from a case study perspective, e.g. by developing examples on how certain drivers may trigger land use change in the region. This step assured that stakeholders understood the meaning of LSH, LSP and LBA. Furthermore, different information material, e.g. a poster explaining LSH/LSP, was shared prior or at the beginning of the workshops so that stakeholders could become familiar with basic concepts.

Guiding questions for the scenario development and the explicit link with the storylines were for instance:

- "Consider the policies, markets, etc. defined by the storyline. Which implications may this have on land use in your region concerning Z?" (Z represents a scenario parameter in Table 1)
- "Where in this region might these changes of Z take place? Can you indicate it on the respective map?"

The stakeholder discussions were supported by figures, tables or maps about the status quo of land use and management. Large format prints of land use maps were provided so that stakeholders could indicate where certain land use changes were most likely to take place. Each case study team summarized the discussion of the first workshop and proposed the resulting scenario drafts to the stakeholder groups for further discussions in a remote feedback loop by e-mail.

Although all case studies followed this common protocol, certain steps offered freedom to adjust to regional specificities such as stakeholder group size and composition. While some groups applied a world café approach (Brown et al., 2005), the ESP team formed three stakeholder groups, with a mixture of different expertise and backgrounds in each group to discuss either LBA, LSH or LSP. In the AT and the NL workshops, stakeholders first discussed LBA, then split into two groups for developing LSH and LSP, and finally discussed all scenarios jointly. In the GER and CH case studies, the stakeholder group discussed all scenarios together. The CH team then held a second workshop with the stakeholders to discuss the refined scenario drafts and to agree on three final scenarios. Group size was the major determinant for the choice of method.

It was not possible to obtain all data for the parameters shown in Table 1 in any of the case studies during the workshops. For missing or qualitatively provided data each case study team either applied expert judgments or quantitative models, depending on the tools and expertise of each research group, prior to the remote feedback loop.

The definition of spatially-explicit land use changes at high resolution can be difficult for stakeholders as well, even if they are regional experts. Hence, the case study teams complemented the land use maps through desk research and fed these results back to the stakeholders. In a first step, land use decision and allocation rules were defined (e.g. Which land use class is increasing at the cost of which other class? or Which spatial characteristics can be used to define land use transition rules (e.g. soil fertility, erodibility, spatial plans)?). In a second step, the rules were fed into a GIS programme to obtain spatially-explicit maps with major land use classes. In each case study, the rules are based on stakeholder information, partly combined with expert knowledge (as in GER and ESP) or existing planning documents (as in NL and ESP).

3. Results

3.1. Current land use in the case studies along the LSH/LSP continuum

Stakeholders were asked to position the current land use in each case study region along the LSP/LSH continuum (Figure 2). In ESP, stakeholders associated current land use to be closest to LBA, with the lowlands being highly intensified and the headwaters largely protected and thus resembling LSP, but with a strong predominance of extensive agro-systems in the middle parts of the basin. GER stakeholders classified the Mulde basin’s current land use as LBA due to having both LSH- and LSP-dominated areas according to the pedo-climatic conditions: the northern part is closer to LSP with large-scale intensive farming on fertile loess soils next to protected, often forested areas on more sandy soils and along the stream network, whereas the southern part (at higher altitudes) appears more heterogeneous with smaller field sizes and higher shares of extensive grassland. In AT, stakeholders saw a situation closer to LSH due to very active participation of farmers in the agri-environmental program, but with a trend towards LSP. In CH, stakeholders agreed that the current state of the landscape was clearly on the LSH side, driven by agricultural policies of the last decades. Against this background, some stakeholders found it difficult to imagine a change towards an extreme LSP vision in CH. The majority of the NL region was classified as close towards LSH, as the landscape is rich in woody linear elements. The southwestern part is a transitional area towards a more LSP-oriented region. This part developed into open polder landscapes, which suits intensive dairy and fruit production on sandy and clay levee deposits of the former riverbed.

Figure 2: Scientists' positioning of current land use along the LSP/LSH continuum for each case study region (AT - Mostviertel in Austria, CH - Broye catchment in Switzerland, GER - Middle Mulde basin in Germany, ESP - Cega Eresma Adaja basin in Spain, NL - Kromme Rijn in the Netherlands) based on stakeholder opinions (Source of maps: Google maps)

3.2. LBA, LSH and LSP scenarios for all case studies

Figure 3 shows the shares of major land use classes in the three scenarios for all case study regions. In all case studies, forest area increased in the LSP scenario since forests would be the natural climax vegetation in most parts of Europe. The largest increase was expected for AT despite its already high current share of forests. Cropland decreased under LSP in all case studies except for GER, where it increased. The loss of agricultural land was lowest in LSH in GER since stakeholders assumed only moderate afforestation (in contrast to LSP) and a reduced soil sealing rate (in contrast to LBA). Interestingly, cropland was still assumed to increase in LSP because the stakeholders assumed a partial conversion of grassland (to cropland) in areas with high soil fertility adjacent to existing cropland. For GER, AT, NL and ESP, the area of permanent grassland declined largely under LSP, while it increased in CH compared to the current situation. With respect to built-up land, there were no major differences between the scenarios in all case studies. In ESP, shrubland is the predominant form of natural vegetation (20% of the total area in 2011). This area remained constant in LSH but increased slightly in LBA (up to 23%) and largely in LSP (up to 37%), mainly due to the abandonment of less productive cropland areas, which was related to a reduction of winter grains. In ESP, the area of permanent grassland increased in LSH compared to today, while no major changes were defined in the other case studies for LSH. This increase was again enabled through the reduction of cropland. Urban areas were expected to increase slightly under both LSH and LSP, but for different reasons in ESP. Under LSH, the increase of urban areas was linked to an inflow migration of citizens from Madrid attracted by the possibility of living closer to nature and due to the technological possibilities that allow working remotely. Under LSP, areas surrounding the protected areas in the upper part were expected to grow in value, fostering the development of urban land. Figure 3 illustrates that differences in land use classes are often larger between case studies than between scenarios for the same region.

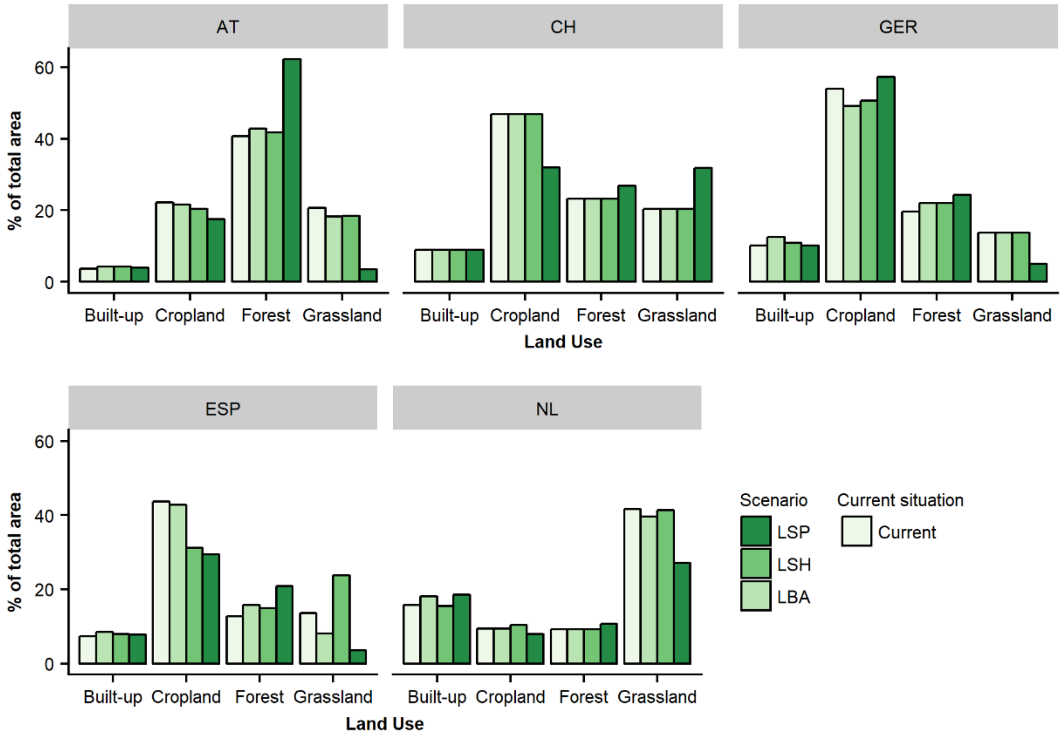

Figure 3: Overview of the shares of major land use classes in the five case study regions for the current situation and the scenarios LBA, LSH and LSP in 2030 (minor classes are missing, hence presented classes do not add up to 100%)

Figure 4 shows the current proportion as well as the development of the major arable crops under the three scenarios for all case study regions for the year 2030. LSP resulted mostly in an increase in maize production except for CH, where production increase of legumes was highest. In AT and GER, other crops than maize or winter grains were largely reduced in LSP, which led to higher specialization and intensification in both regions. In ESP, the area used for winter grains, legumes and temporary grasslands was lower in LSP compared to today so that the proportion of land used for producing maize and other crops (mostly horticulture, which are not shown in Figure 4) could increase.

In all case studies, the cultivated crops became more diverse in LSH as compared to the current situation. In NL, where cropland is limited to maize production in the current situation, maize still dominated in LSH but with some uptake of other fodder crops. In CH, all crop rotations were assumed to incorporate 10% grain legumes, leading to a reduction of winter grains. In AT, maize was reduced, which enabled an increase in temporary grassland and in more diverse winter grains. In GER, less rapeseed and sugar beet were cultivated, which enabled increases in barley, rye, wheat, maize and temporary grassland. In ESP, the area of winter grains, maize, other grains and sugar beet was reduced such that more legumes could be cultivated in LSH compared to the current situation. However, agricultural landscapes remained strongly dominated by winter grains. Maize was the second most important crop in all scenarios for ESP.

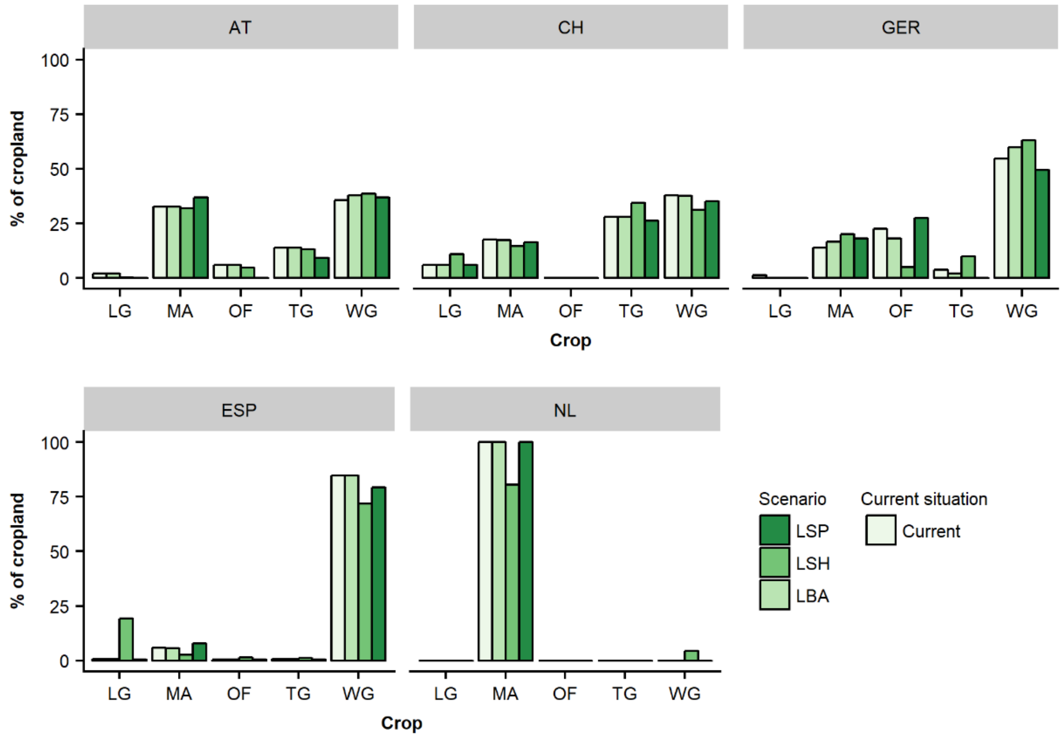

Figure 4: Overview of the share of most important crops on total cropland in each case study region for the scenarios LBA, LSH and LSP in 2030 (minor crops are missing, hence presented crops do not necessarily add up to 100% (abbreviations: LG = Legumes, MA = Maize, OF= Oleaginous fruits, TG = Temporary grassland, WG = Winter grains)

Figure 5 shows the derived land use maps for AT and GER with the remaining case study regions presented in Appendix D. The map for LSP in AT clearly shows the large increase of forest, which is mainly located in the South, where nearly all permanent grassland was abandoned and likely reforests naturally (Figure 5f). The maps of GER show for instance that intensive permanent grassland is transformed to extensive permanent grassland in LSH (Figure 5b).

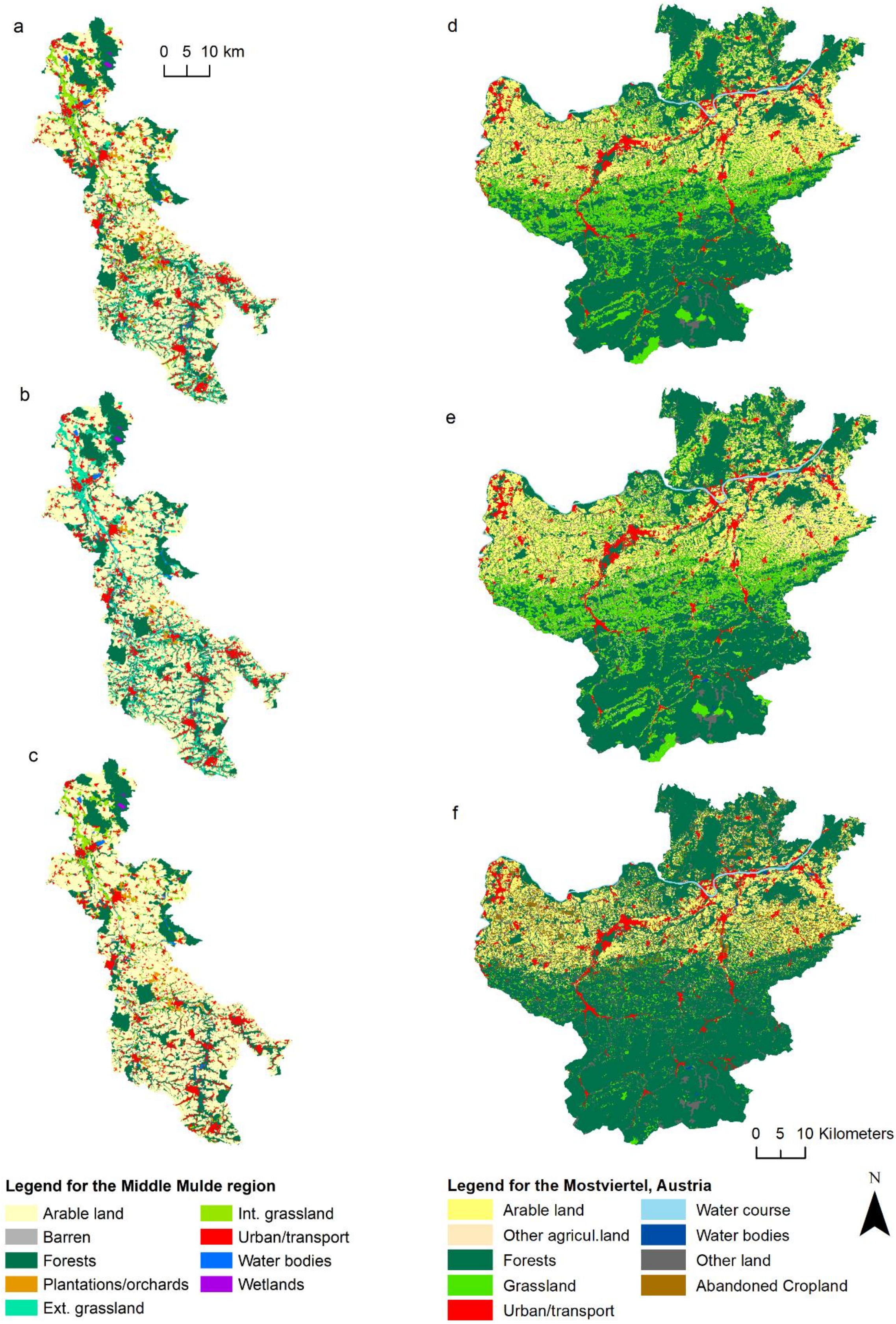

Figure 5: Land use maps for a) LBA, b) LSH and c) LSP in the Mulde region in Germany (GER) and d) LBA, e) LSH and f) LSP in the Mostviertel region in Austria (AT) in 2030

Table 2 lists the management changes across scenarios for 2030. Stakeholders defined possibilities to increase management intensities in LSP compared to LBA in nearly all case studies, while they defined decreases for LSH. For instance, the ploughed area was largest in LSP in GER. In AT, a high share of cropland was managed with mulch and direct seeding in LSP, because stakeholders assumed that glyphosate would be still allowed, while it would be banned in the other scenarios. In LSH, subsidies would increase the area managed with mulch and direct seeding compared to LBA. In CH, sugar beet and potato would be irrigated in LSP. The share of organic farming was lowest under LSP in all case studies as well, while it was largest under LSH. However, an increase of organic farming was defined for LSP compared to today in NL. In AT, GER and CH, linear landscape elements were largely removed from managed farmland in LSP, while their density increased in LSH. For example, it would double in CH. In AT, the ecological compensation area (i.e. set-aside land) would increase from 0.5% to 7% of the total agricultural area in LSH. Changes in fertilisation intensities varied across scenarios and regions. For instance, in GER, ESP and CH, the nitrogen fertilisation intensity of grassland under LSP was more than double the intensity of LSH. While in GER fertilisation intensities on cropland and grassland increased from LSH to LBA to LSP, intensities did not vary between LBA and LSP in ESP. There would be little further intensification in NL in LSP compared to LBA, since agriculture was already managed very intensively there. Nevertheless, livestock densities were expected to increase in the LSP scenario and decrease in LSH, while the area of extensive grassland was expected to expand strongly in LSH.

In LSP, cover crops were reduced in GER and in AT to 0% and 7%, respectively. While the area of cover crops amounted to 1% of cropland in GER and 32% of cropland in AT region in LBA, it increased under LSH to 5% in GER and to 42% in AT. In NL, no changes for cover crops across the scenarios were defined.

In LSP, nature protection sites increased in all case study regions. In AT, all extensively managed grasslands, mainly located in marginal areas and abandoned in LSP, would be put under nature protection by law. A similar situation would occur in ESP, where many of the cropland and grasslands areas were protected in the more marginalized parts. In CH, areas with low soil fertility would be turned into nature protection areas (permanent grassland, which requires minimum maintenance). If such areas are in proximity to existing areas of high nature value, the unproductive land can be used to extend these areas. In NL, nature protection areas would increase in LSH compared to LBA.

Other contrasting developments between the scenarios and case studies are for instance an increase of river buffer strips in LBA and in LSP in CH (10m-20m width to both sides), while stakeholders defined such an enlargement of buffers for LSH (15m width to both sides) and kept only the current legal minimum in LSP and no change for LBA in AT.

Table 2: Overview of the development of land management by the scenarios LBA, LSH and LSP in each case study region in 2030.

	Case study	GER				AT				CH				NL				ESP			
Parameter/ Management	**Unit**	2014-2016	LBA	LSH	LSP	2015	LBA	LSH	LSP	2015	LBA	LSH	LSP	2016	LBA	LSH	LSP	2011	LBA	LSH	LSP
Irrigated cropland	% of cropland & orchards	0%	0%	0%	0%	0%	0%	0%	0%	4%	4%	0%	30%	41%	36%	41%	45%	9%	17%	4%	19%
Rain fed cropland		100%	100%	100%	100%	100%	100%	100%	100%	96%	96%	100%	70%	59%	64%	59%	55%	89%	83%	96%	79%
Soil management:	% of cropland																				
Plough		40%	30%	0%	40%	89%	89%	79%	80%	98%	98%	98%	98%	46%	n.a.	n.a.	n.a.	96%	96%	96%	96%
Mulch and direct seeding						11%	11%	21%	20%	1%	1%	1%	1%	12%	n.a.	n.a.	n.a.	4%	4%	4%	4%
Minimum tillage		60%	70%	100%	60%					1%	1%	1%	1%		n.a.	n.a.	n.a.				
Organic farming	% of agricult-ural land	3%	4%	16%	0%	13%	12%	20%	2%	19%	19%	24%	13%	18%	33%	52%	28%	n.s.	n.s.	n.s.	n.s.
Fertilization intensity, cropland:	kg/ha																				
N		156	145	104	168	158*	160*	148*	202*	147	118	101	151	160	160	140	160	119	119	83	119
P		41	40	36	47	75*	74*	70*	90*	n.a.	n.a.	n.a.	n.a.	60	60	52	60	89	89	36	89
Fertilization intensity, grassland:	kg/ha																				
N (extensive/intensive)		90/ 140	85/ 130	60	140	15/ 124*	14/ 125*	14/ 115*	-/ 146*	50/ 120	104	50	120	345	345	345	345	180	180	83	180
P (extensive/intensive)		20/ 35	20/ 32	20	35	6/ 48*	5/ 48*	5/ 45*	-/ 57*	n.a.	n.a.	n.a.	n.a.	90	90	90	90	40	40	36	40
Livestock density	Livestock unit / ha	n.a.	n.a.	n.a.	n.a.	1.2	1.5	1	1.5	3	3	1	4	4.5	4.2	3.3	5.1	n.a.	n.a	n.a.	n.a.

*Model results according to scenario input data

Note: n.s. – not specified, n.a. – not applicable

3.3. Evaluation of the scenarios by the stakeholders

In the second round of workshops, which took place in 2018 (one year after the first workshops), stakeholders were asked to choose the most plausible and most preferable scenario among the three. While stakeholders preferred LSH in the GER case study, the majority preferred LBA in AT due to a balance between agricultural production and biodiversity. In CH, stakeholders had the highest preference for LBA, followed by LSH and the lowest preference for LSP.

Stakeholders stressed that mainly the political frame conditions determine the plausibility of a scenario in AT. In CH, GER and AT stakeholders agreed that the balanced scenario LBA is the most plausible one, since no major changes regarding land use and current policies are required. In GER and CH, stakeholders considered both strategies, LSH and LSP as unrealistic, since LSH requires consumers to accept higher prices for agricultural products and land use would have to change too dramatically in LSP, which is unlikely given the landscape characteristics in the case study region. In AT, stakeholders evaluated LSP as unlikely. For instance, one stakeholder highlighted that even if LSP would be preferable from an ecological aspect, no Austrian politician would dare to say that a certain percentage of cropland should be spared and taken out of production. Nevertheless, other statements reveal some contradictory perspectives with respect to the plausibility of LSP. For instance, stakeholders agreed that the current situation and most recent land use trends (i.e. intensification of cropland, loss of grassland, increasing field size) direct more towards LSP landscapes. Hence, the preferred LBA situation would require policies or subsidies to change. On the other hand, environmental protection regulations, e.g. the Water Framework Directive, would be in place in any scenario and limit further intensification according to the AT stakeholders. They interpreted past land use in AT as an example for LSH (e.g. small field sizes with many landscape elements). Unrealistically high subsidies, however, would be required to bring back these past landscapes. The NL stakeholders judged the LSP scenario as unrealistic and undesired, as it does not fit today's highly appreciated landscape characteristics in major parts of the region. The Kromme Rijn region is currently undergoing a trend of diversification of farming activities that is closely linked to its heterogeneous landscapes, e.g. by focusing on landscape recreation. It is deemed unlikely that this diversification trend will reverse. The stakeholders also raised concerns how increased population density in the area, together with the related increased recreation pressure, would match further intensification of agriculture. Concerns about landscape attractiveness for recreationists were raised, as well as health risks due to PM10 and other air pollution from intensive agriculture. The stakeholders evaluated the LSH scenario as being close to the current situation. However, they raised concerns about the viability of the agricultural sector in the region in this scenario.

In ESP, stakeholders agreed that LSH would be the most desirable but also most unrealistic scenario. LBA was seen as the most probable since it somehow reflects current land use trends and hence does not require any substantial deviations from the current situation, especially when considering a time horizon until 2030. Stakeholders enumerated a number of sometimes interlinked factors explaining the constraints for LSH to become plausible. On the one hand, stakeholders indicated that any increase of the EU budget for agri-environment-climate measures does not necessarily translate into more funds made available for farmers. Most importantly, this will require real engagement and commitment of the regional government, which is very much governed by the idea that only agricultural intensification will allow the continuation of agriculture in this region given its environmental and socioeconomic settings. Related to this, the feasibility of expanding the production of ecological products is constrained by the limited market that exists in Spain for ecological products if compared to countries like Austria. Another important factor is the low efficiency of the agricultural value chain in the region, i.e. very low cooperation at the producers' level and high concentration at the distribution level. The consequence as indicated by some farmers is that the retailers define the price and farmers need to reduce costs and increase productivity as much as possible.

4. Discussion and conclusions

4.1. Operationalization of LSH/LSP in a regional vs. global context

This multi-scale scenario approach operationalized the LSH/LSP concept at regional scale. The selection of a common global storyline, three LSH/LSP/LBA storylines for Europe and a scenario protocol led to comparable land use scenarios at case study level. However, when defining scenarios caution is required with respect to the scaling of LSH/LSP in such a multi-scale setting (see discussion point 4.4) because the meaning of LSH/LSP is highly scale dependent (von Wehrden et al., 2014) with further diverse interpretations of LSH/LSP coming from the stakeholders. For instance, LSH or LSP could be operationalized for the entire European continent, within single countries or within sub-country regions such as the case studies. This challenge was tackled by considering several hierarchical levels and by developing storylines or scenarios for LSH and LSP for each level. Storylines for LSH, LSP and LBA were defined at European level with the help of the project advisory board and respective land use implications were then delineated at the case study level through parallel scenario processes by including local stakeholders. Nevertheless, the resulting land use scenarios are case study-specific and influenced by the chosen spatial resolution. The spatial scale of LSH and LSP in the final scenarios is similar among the case studies, where stakeholders considered fields and field aggregates as units for either LSH or LSP choices. Anyhow, LSP could also be understood as management at much smaller scales, e.g. hedges or grass strips between fields. In the case studies, stakeholders typically attributed such management choices as part of LSH.

According to Zurek and Henrichs (2007), scenarios can be linked across scales either through common scenario elements or coupled scenario processes. Scenario elements are comparable if they have a similar analytical framework or shared concepts. Coherent scenario elements, which follow the same paradigm, can be ensured through common driving forces, major trends or scenario outcomes. Coupled scenario processes can be either joint, parallel, iterative, consecutive or independent (Zurek and Henrichs, 2007). This multi-scale scenario approach follows first a consecutive scenario process for defining the storylines for Europe and then a parallel process for defining the case study-specific land use scenarios, where the European storylines represent the common framework and scenario elements. Maintaining consistency or coherency among the scenarios when using a parallel process is challenging, however, through using a scenario protocol and defining scenarios with common elements (the minimum scenario parameters), consistency and coherency were ensured in this multi-scale scenario approach. Hence, the final case study-specific land use scenarios are comparable to some extent.

In the literature, there is an increasing number of multi-scale scenario studies, which build and link scenarios on several scales (Biggs et al., 2007; Wardropper et al., 2016). The different world views and assumptions of stakeholders at different levels have to be considered when down- or upscaling particular views. In general, previous experiences have shown that the incorporation of local stakeholders within a participatory process is easier than engaging stakeholders at higher levels (Kok et al., 2007). Nevertheless, multi-scale scenario processes may require multi-scale stakeholder processes as well. Different stakeholders were involved for the different hierarchical levels of scenarios in the presented research process, e.g. the members from the project advisory board participated in the development of the European level storylines and local stakeholders from each case study region in the development of the case study-specific scenarios. However, a third level could have been introduced using the expertise of national level stakeholders – beyond advisory board experts – to ease the transition from European level developments to the case study level. This might have been advantageous since not all stakeholders were familiar with developments at the European scale and their likely regional impacts.

4.2. Transformation of qualitative and quantitative land use information obtained from stakeholders into quantitative spatially-explicit information

The challenges of transforming qualitative or quantitative land use information from stakeholders to spatially-explicit information are well documented (Booth et al., 2016; Mallampalli et al., 2016). In this study, the purpose of developing land use scenarios was to model the impacts on ES and biodiversity. Hence, the aimed level of scenario details was high (pixel resolution outcomes) and the required information was specific and technical, thus confining the process to scientific experts (Mallampalli et al., 2016). In such a case, potential biases could have emerged as low resolution choices of stakeholders were translated to high resolution outcomes. This requires methodological standards and specific consideration when communicating results.

In all case studies, stakeholders first discussed how a certain parameter (e.g. forest area, cropland) might qualitatively change under a particular storyline. To map those changes, different methods had to be used to translate the processes behind the land use changes expected in the case study region. Stakeholders either directly allocated potential transition areas or agreed on general transition rules. While the drivers of transitions were either based on bio-physical processes or policies, the allocation of these changes or transition rules were mostly process-based and case study-specific. For instance, in CH stakeholders oriented themselves on bio-physical processes to allocate changes. They defined clear slope or soil suitability thresholds for transforming cropland to intensive grassland or specified that woodland areas should remain in LSH since they are already a scarce land cover class in the region. In ESP, the loss of cropland was related to productivity. Low productive land is re-naturalized to increase the ecological connectivity in LSH and high productive land is intensified to grow crops of high added value. On the contrary, the stakeholders involved in GER related land cover changes to two main developments, which were expected to continue in each scenario: 1) ecological afforestation due to the corresponding program of the Saxonian Ministry for the Environment and Agriculture (Lautenbach et al., 2017; Saxonian Ministry for the Environment and Agriculture, 2007), and 2) soil sealing for urban areas and infrastructures. In general, soil fertility, potential erosion risk and distance measures were used to allocate land use changes in GER. In AT, for instance, permanent grassland loss as well as the abandonment of cropland were clearly related to changes in agri-environment-climate measures funding in LSP. Land use changes of these losses were process-based, e.g. these areas would reforest naturally. In NL, stakeholders indicated that grasslands close to the Rhine river would likely be converted into natural land under LSP or that the centre zone of the study region would likely face an increase of scattered built-up area with LSH.

Since stakeholders have based land use changes on different rules in each case study, a common scenario process, as shown in this study, requires a high level of flexibility in order to incorporate the local context adequately. Still, comparability and consistency of the results need to be ensured, via e.g. minimum scenario parameters and developing land use maps with common land cover and land use classes.

4.3. The role of the case study context when defining stakeholder-based scenarios of LSH and LSP

Scenario development is specific to regional characteristics (e.g. bio-physical conditions and farm structure) but outcomes may also be influenced by other factors such as the participating stakeholders or the public discourse at a certain point in time. This section reflects on the potential role of these factors in the scenario development process.

Representativeness of viewpoints is a function of group size. The number of stakeholders varied from five to 24. In some case studies substantially less stakeholders attended the workshops than have been invited. A main reason for absence was time constraints indicating the well documented 'stakeholder fatigue' (Gramberger et al., 2015) in stakeholder processes. Thus, stakeholders were asked to take a representative instead of personal perspective where appropriate.

With regard to the group composition (i.e. type of stakeholders) of the scenario workshops it is unclear whether the selection of stakeholders indeed influenced land use patterns in the LSH, LSP and LBA scenarios. In AT and GER, the stakeholders represented different institutions but showed a consensus on the need for nature-friendly food and biomass production. A larger weight of production-oriented farmers may have impacted group discussions and eventually the land use outcomes for the scenarios. For instance, the NL stakeholders showed a large deviation between the views of the farmers' and policy/NGO representatives, with the former more focussed on issues regarding economic feasibility, intensification and preferred level of administrative control. A general negative view on the agricultural feasibility by the farmers' representatives in NL might have influenced the discussion towards a more negative view of enhanced LSH. However, the region has an institutionalized stakeholder processes (i.e. "Area commission") which makes stakeholders used to these deliberation processes. It is therefore recommended to spend considerable efforts on ensuring that stakeholder boards not only include the most important representatives, but also hold differing viewpoints, which was also highlighted in other scenario studies, e.g. Metzger et al. (2010) or Wardropper et al. (2016). This could be done by asking questions on views and preferences regarding future land use patterns during the recruitment process but is constrained by the limited interest and availability of stakeholders.

With regard to the regional characteristics, it is well known that LSH/LSP is scale dependent and that effects on landscape functions are related to the land use history (Grau et al., 2013; von Wehrden et al., 2014). Hence, the regional characteristics provide the frame for future land use opportunities. Consequently, strict LSP or LSH interpretations might be perceived as unrealistic. For example, traditional landscapes with orchards and small landscape elements, as well as small farm sizes, were seen as unlikely for intensification or land abandonment required for LSP in AT or NL. In NL, the stakeholders explicitly identified other regions in the Netherlands as more likely for LSP. In CH, stakeholders also saw LSP as unrealistic due to bio-physical constraints. In ESP, stakeholders highlighted regional bio-physical conditions such as poor soil quality and water stress as well as economic factors, i.e. low agricultural profitability and a highly inefficient agricultural value chain (i.e. low cooperation among producers and lack of entrepreneurship). Nevertheless, ESP stakeholders deemed LSH as unrealistic due to the predominant structure of large commercial farms and fields with few landscape elements. The group discussions in all case study regions reveal that stakeholders consider a wide range of site-specific characteristics in the scenario development.

4.4. Challenges and achievements of the scenario and stakeholder process

The complexity and abstractness of the LSH/LSP concept was a challenge for the stakeholder process in some case studies, such as CH, ESP and NL. Difficulties were also related to the scales where LSH and LSP are or should be defined. There is no unique way of implementing either of the two extreme strategies, but both exist rather on a LSH/LSP continuum. Generally, LSH and LSP are scale-dependent (Fischer et al., 2014; Quinn et al., 2012) and different authors define them on different scales. For instance, LSH could be interpreted as LSP on a smaller scale, as done by Chandler et al. (2013), Egan and Mortensen (2012) or Quinn et al. (2012), who defined either set-aside land or landscape elements as LSP on the field scale. Furthermore, the LSH and LSP concept was criticized for its dichotomous view in previous studies, as well as by some of the stakeholders. Many authors argue that a combination of both might be the best option (e.g. Kremen, 2015; Tscharntke et al., 2012a or Wright et al., 2012). Assessing these two extremes, along with an intermediary (LBA) strategy, however, allows to show a bandwidth of options and differences with relevance for the local population. Furthermore, it enables comparison among different case studies. Moreover, defining and evaluating extreme scenarios likely has stimulated discussions among stakeholders more than scenarios with only small changes in land cover and management would have (e.g. Booth et al., 2016).

Another challenge is related to the high level of abstraction that quickly evokes denial and doubts. Stakeholders perceived the scenarios as quite complicated. For example, 'understanding and translating scenarios' was mentioned as one of the main challenges in the evaluation questionnaire after the workshop in NL. Challenges of understanding these concepts hence partly stemmed from the difficulty of understanding academic top-down concepts with international relationships. A way forward are translations to known terminology and regional real-world examples. For example, the Spanish case study team translated LSH/LSP into simpler and more common ideas (e.g. LSP as "towards the specialization of the territory" or LSH as "towards multifunctional landscapes"), which worked well.

The level of detail, which was required for the subsequent modelling, e.g. regarding crop rotations, pest management and fertilization (i.e. the scenario parameters, see Table 1), was challenging during the workshops and beyond. The parameter settings required high technical expertise and detailed knowledge. On the one hand, stakeholders of a particular region are not necessarily experts for all topics and parameters discussed when developing scenarios. On the other hand, experts of certain topics (e.g. pest management) are not necessarily regional stakeholders. Hence, when defining scenarios, it is also important to ensure that experts of certain topics are included in the scenario development. Furthermore, stakeholders were asked to take a regional instead of personal view point for the scenario development, to which many stakeholders might not have been used to and felt uncomfortable. Most stakeholders therefore hesitated to mention specific numbers and some argued that they were not sure of the baseline values to define scenario projections – even those stakeholders with unarguably high regional expertise. This feeling of uncertainty remained even when stakeholders were provided with the baseline data and current trends and information on single parameters such as in the NL or AT case studies. In CH, for example, stakeholders requested further information to make well-informed decisions such as maps on soil suitability, slopes and other factors helping to determine the allocation of particular management changes. As a consequence, all case studies have discussed most changes qualitatively or in relative ranges.

Furthermore, it was difficult to map particular changes spatially-explicit since many stakeholders were reluctant to visualize the changes for different reasons: Some stakeholders were afraid to choose definitive numbers, others did not know where exactly in the case study region these changes could occur.

Another challenge of the process was the 15-year time span until 2030. It was considered as too short by stakeholders for any substantial changes to occur and for overcoming current inertia in ESP, NL and AT. However, the scenario definition would have been possible even without an explicit time horizon. It was defined to frame the discussions and give orientation to stakeholders, which turned out to be counterproductive in some cases.

Some stakeholders were reluctant to envision any changes, especially in GER and CH. They feared that research results might influence agricultural policies and lead to the introduction of new regulations. In general, good moderation was essential to encourage stakeholders to think out of the box (see Hagemann et al., 2018). On the one hand, moderation helped that stakeholders became more open to imagine and visualize certain scenarios. On the other hand, it reduced the dominance of the agricultural perspective in the dialogue, which was present in some case studies.

Some achievements, which were not core of the workshop a priori, were for instance that land use and management related environmental issues could be identified, as well as possible ways of mitigating these effects, especially in CH. In the GER and ESP case studies, stakeholders provided valuable information on data availability and on the situation of the administration and the farmers in general.

4.5. Conclusions for the development of future land use policies

The scenarios mostly preferred by stakeholders, i.e. LBA and LSH, have to be accompanied by policy measures. Some minimum standards, e.g. regarding fertilizer and pesticides use, can be regulated area-wide. “Simple” agri-environment-climate measures may be offered across a large administrative region. However, especially nature conservation activities require targeting or adaptation of measures to local conditions (e.g. Batáry et al., 2015). This requires an involvement of regional and local actors and cooperation among land managers (Westerink et al., 2017). Overall, EU and Switzerland have developed complex systems of policy instruments for steering agricultural land use (Nitsch et al., 2017). While the need for information and advice, offered independently from enforcement, has been stressed in AT and GER, the cooperative aspect is particularly visible in NL. Based on a long history of experiences with environmental cooperation and agricultural producer groups, agri-environment-climate measures are only eligible for farmers’ collectives from 2016 onwards. Such approaches and also other forms of regional action have the potential to encourage communication and an active engagement of land managers with the environment and are thus bound to be effective and have lasting effects on environmental awareness.

4.6. Summary and conclusion

The presented hierarchical multi-scale scenario approach has proven successful to develop case study-specific, spatially-explicit land use scenarios. This approach complements empirical research on LSH and LSP by using multi-scale scenarios for several different countries and integrating local stakeholders for scenario definition. Comparability between different case study regions was ensured through a parallel scenario definition process, which was guided by a common scenario protocol and common scenario elements. Furthermore, the flexibility of this approach allowed that each case study focused on specific local circumstances besides the common scenario elements. Overall, this study reveals several challenges for scenario definition with stakeholders and the importance of a well-designed scenario process, especially in the LSH and LSP context or when defining extreme scenarios. Stakeholders in most case studies agreed on the most preferable and most likely scenarios (LSH, LBA) with some skepticism towards LSP. Preference of scenarios – and vice versa skepticism towards others – was closely linked to current land use patterns in the case study regions. For example, LSH was preferred and LSP deemed as unrealistic in landscapes with traditionally many orchards or small landscape elements as in the AT, NL and CH case studies.

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References

Alcamo, J., Kok, K., Busch, G., Priess, J.A., Eickhout, B., Rounsevell, M., Rothman, D.S., Heistermann, M., 2006. Searching for the Future of Land: Scenarios from the Local to Global Scale, in: Lambin, E.F., Geist, H. (Eds.), Land-Use and Land-Cover Change. Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 137–155. https://doi.org/10.1007/3-540-32202-7_6

Balmford, A., Green, R., Phalan, B., 2015. Land for food & land for nature? Daedalus 144, 57–75. https://doi.org/10.1162/DAED_a_00354

Balmford, A., Green, R.E., Scharlemann, J.P.W., 2005. Sparing land for nature: Exploring the potential impact of changes in agricultural yield on the area needed for crop production. Global Change Biology 11, 1594–1605. https://doi.org/10.1111/j.1365-2486.2005.001035.x

Batáry P., Dicks L.V., Kleijn D., Sutherland W.J., 2015. The role of agri-environment schemes in conservation and environmental management. Conservation Biology 29, 1006–1016. https://doi.org/10.1111/cobi.12536

Biggs, R., Raudsepp-Hearne, C., Atkinson-Palombo, C., Bohensky, E., Boyd, E., Cundill, G., Fox, H., Ingram, S., Kok, K., Spehar, S., Tengö, M., Timmer, D., Zurek, M., 2007. Linking Futures across Scales: a Dialog on Multiscale Scenarios. Ecology and Society 12. https://doi.org/10.5751/ES-02051-120117

Booth, E.G., Qiu, J., Carpenter, S.R., Schatz, J., Chen, X., Kucharik, C.J., Loheide, S.P., Motew, M.M., Seifert, J.M., Turner, M.G., 2016. From qualitative to quantitative environmental scenarios: Translating storylines into biophysical modeling inputs at the watershed scale. Environmental Modelling & Software 85, 80–97. https://doi.org/10.1016/j.envsoft.2016.08.008

Brown, J., Isaacs, D., Thw World Café Community, 2005. The World Café: Shaping our futures through conversations that matter. Berrett-Koehler Publishers, Inc., San Francisco, California.

Carpenter, S.R., Booth, E.G., Gillon, S., Kucharik, C.J., Loheide, S., Mase, A.S., Motew, M., Qiu, J., Rissman, A.R., Seifert, J., Soylu, E., Turner, M., Wardropper, C.B., 2015. Plausible futures of a social-ecological system: Yahara watershed, Wisconsin, USA. Ecology and Society 20. https://doi.org/10.5751/ES-07433-200210

Chandler, R.B.. d, King, D.I.., Raudales, R.., Trubey, R.., Chandler, C.., Arce Chávez, V.J.., 2013. A small-scale land-sparing approach to conserving biological diversity in tropical agricultural landscapes. Conservation Biology 27, 785–795. https://doi.org/10.1111/cobi.12046

Cord, A.F., Bartkowski, B., Beckmann, M., Dittrich, A., Hermans-Neumann, K., Kaim, A., Lienhoop, N., Locher-Krause, K., Priess, J., Schröter-Schlaack, C., Schwarz, N., Seppelt, R., Strauch, M., Václavík, T., Volk, M., 2017. Towards systematic analyses of ecosystem service trade-offs and synergies: Main concepts, methods and the road ahead. Ecosystem Services. https://doi.org/10.1016/j.ecoser.2017.07.012

Duru, M., Therond, O., Martin, G., Martin-Clouaire, R., Magne, M.-A., Justes, E., Journet, E.-P., Aubertot, J.-N., Savary, S., Bergez, J.-E., Sarthou, J.P., 2015. How to implement biodiversity-based agriculture to enhance ecosystem services: a review. Agron. Sustain. Dev. 35, 0. https://doi.org/10.1007/s13593-015-0306-1

Edwards, D.P., Gilroy, J.J., Woodcock, P., Edwards, F.A., Larsen, T.H., Andrews, D.J.R., Derhé, M.A., Docherty, T.D.S., Hsu, W.W., Mitchell, S.L., Ota, T., Williams, L.J., Laurance, W.F., Hamer, K.C., Wilcove, D.S., 2013. Land-sharing versus land-sparing logging: reconciling timber extraction

with biodiversity conservation. Global Change Biology n/a–n/a. https://doi.org/10.1111/gcb.12353
Egan, J.F., Mortensen, D.A., 2012. A comparison of land-sharing and land-sparing strategies for plant richness conservation in agricultural landscapes. Ecological Applications 22, 459–471. https://doi.org/10.1890/11-0206.1
Fischer, J., Abson, D.J., Bergsten, A., French Collier, N., Dorresteijn, I., Hanspach, J., Hylander, K., Schultner, J., Senbeta, F., 2017a. Reframing the Food–Biodiversity Challenge. Trends in Ecology & Evolution 32, 335–345. https://doi.org/10.1016/j.tree.2017.02.009
Fischer, J., Abson, D.J., Butsic, V., Chappell, M.V., Ekroos, J., Hanspach, J., Kuemmerle, T., Smith, H.G., von Wehrden, H., 2014. Land sparing versus land sharing: moving forward. Conservation Letters 7, 149–157. https://doi.org/10.1111/conl.12084
Fischer, J., Brosi, B., Daily, G.C., Ehrlich, P.R., Goldman, R., Goldstein, J., Lindenmayer, D.B., Manning, A.D., Mooney, H.A., Pejchar, L., Ranganathan, J., Tallis, H., 2008. Should agricultural policies encourage land sparing or wildlife-friendly farming? Frontiers in Ecology and the Environment 6, 380–385. https://doi.org/10.1890/070019
Fischer, J., Meacham, M., Queiroz, C., 2017b. A plea for multifunctional landscapes. Frontiers in Ecology and the Environment 15, 59. https://doi.org/10.1002/fee.1464
Gabriel, D., Sait, S.M., Kunin, W.E., Benton, T.G., 2013. Food production vs. biodiversity: comparing organic and conventional agriculture. Journal of Applied Ecology n/a–n/a. https://doi.org/10.1111/1365-2664.12035
Godfray, H.C.J., 2011. Food and biodiversity. Science 333, 1231–1232. https://doi.org/10.1126/science.1211815
Gramberger, M., Zellmer, K., Kok, K., Metzger, M.J., 2015. Stakeholder integrated research (STIR): a new approach tested in climate change adaptation research. Climatic Change 128, 201–214. https://doi.org/10.1007/s10584-014-1225-x
Grau, R., Kuemmerle, T., Macchi, L., 2013. Beyond 'land sparing versus land sharing': environmental heterogeneity, globalization and the balance between agricultural production and nature conservation. Current Opinion in Environmental Sustainability 5, 477–483. https://doi.org/10.1016/j.cosust.2013.06.001
Green, R.E., Cornell, S.J., Scharlemann, J.P.W., Balmford, A., 2005. Farming and the Fate of Wild Nature. Science 307, 550–555. https://doi.org/10.1126/science.1106049
Hagemann, N., van der Zanden, E.H., Willaarts, B., Holzkämper, A., Volk, M., Rutz, C., Schönhart, M., 2017. Bringing the sharing-sparing debate down to the ground – Lessons learnt for participatory scenario development. Unpublished manuscript.
Harrison, P.A., Berry, P.M., Simpson, G., Haslett, J.R., Blicharska, M., Bucur, M., Dunford, R., Egoh, B., Garcia-Llorente, M., Geamănă, N., Geertsema, W., Lommelen, E., Meiresonne, L., Turkelboom, F., 2014. Linkages between biodiversity attributes and ecosystem services: A systematic review. Ecosystem Services 9, 191–203. https://doi.org/10.1016/j.ecoser.2014.05.006
Hodgson, J.A., Kunin, W.E., Thomas, C.D., Benton, T.G., Gabriel, D., 2010. Comparing organic farming and land sparing: Optimizing yield and butterfly populations at a landscape scale. Ecology Letters 13, 1358–1367. https://doi.org/10.1111/j.1461-0248.2010.01528.x
Hulme, M.F., Vickery, J.A., Green, R.E., Phalan, B., Chamberlain, D.E., Pomeroy, D.E., Nalwanga, D., Mushabe, D., Katebaka, R., Bolwig, S., Atkinson, P.W., 2013. Conserving the Birds of Uganda's Banana-Coffee Arc: Land Sparing and Land Sharing Compared. PLoS ONE 8. https://doi.org/10.1371/journal.pone.0054597
Isbell, F., Tilman, D., Polasky, S., Loreau, M., 2015. The biodiversity-dependent ecosystem service debt. Ecol Lett 18, 119–134. https://doi.org/10.1111/ele.12393
Kanter, D.R., Musumba, M., Wood, S.L.R., Palm, C., Antle, J., Balvanera, P., Dale, V.H., Havlik, P., Kline, K.L., Scholes, R.J., Thornton, P., Tittonell, P., Andelman, S., 2016. Evaluating agricultural trade-offs in the age of sustainable development. Agricultural Systems. https://doi.org/10.1016/j.agsy.2016.09.010

Kok, K., Biggs, R. (Oonsie), Zurek, M., 2007. Methods for Developing Multiscale Participatory Scenarios: Insights from Southern Africa and Europe. Ecology and Society 12. https://doi.org/10.5751/ES-01971-120108

Kok, K., Patel, M., Rothman, D.S., Quaranta, G., 2006. Multi-scale narratives from an IA perspective: Part II. Participatory local scenario development. Futures 38, 285–311. https://doi.org/10.1016/j.futures.2005.07.006

Kremen, C., 2015. Reframing the land-sparing/land-sharing debate for biodiversity conservation. Ann. N.Y. Acad. Sci. n/a-n/a. https://doi.org/10.1111/nyas.12845

Lamarque, P., Artaux, A., Barnaud, C., Dobremez, L., Nettier, B., Lavorel, S., 2013. Taking into account farmers' decision making to map fine-scale land management adaptation to climate and socio-economic scenarios. Landscape and Urban Planning 119, 147–157. https://doi.org/10.1016/j.landurbplan.2013.07.012

Lautenbach, S., Jungandreas, A., Blanke, J., Lehsten, V., Mühlner, S., Kühn, I., Volk, M., 2017. Trade-offs between plant species richness and carbon storage in the context of afforestation – Examples from afforestation scenarios in the Mulde Basin, Germany. Ecological Indicators 73, 139–155. https://doi.org/10.1016/j.ecolind.2016.09.035

Law, E.A., Meijaard, E., Bryan, B.A., Mallawaarachchi, T., Koh, L.P., Wilson, K.A., 2015. Better land-use allocation outperforms land sparing and land sharing approaches to conservation in Central Kalimantan, Indonesia. Biological Conservation 186, 276–286. https://doi.org/10.1016/j.biocon.2015.03.004

Lee, H., Lautenbach, S., 2016. A quantitative review of relationships between ecosystem services. Ecological Indicators 66, 340–351. https://doi.org/10.1016/j.ecolind.2016.02.004

Lindborg, R., Gordon, L.J., Malinga, R., Bengtsson, J., Peterson, G., Bommarco, R., Deutsch, L., Gren, Å., Rundlöf, M., Smith, H.G., 2017. How spatial scale shapes the generation and management of multiple ecosystem services. Ecosphere 8, e01741. https://doi.org/10.1002/ecs2.1741

Lindborg, R., Stenseke, M., Cousins, S.A.O., Bengtsson, J., Berg, Å., Gustafsson, T., Sjödin, N.E., Eriksson, O., 2009. Investigating biodiversity trajectories using scenarios – Lessons from two contrasting agricultural landscapes. Journal of Environmental Management 91, 499–508. https://doi.org/10.1016/j.jenvman.2009.09.018

Luskin, M.S., Lee, J.S.H., Edwards, D.P., Gibson, L., Potts, M.D., 2017. Study context shapes recommendations of land-sparing and sharing; a quantitative review. Global Food Security. https://doi.org/10.1016/j.gfs.2017.08.002

Macchi, L., Grau, H.R., Zelaya, P.V., Marinaro, S., 2013. Trade-offs between land use intensity and avian biodiversity in the dry Chaco of Argentina: A tale of two gradients. Agriculture, Ecosystems and Environment 174, 11–20. https://doi.org/10.1016/j.agee.2013.04.011

Maes, J., Paracchini, M.L., Zulian, G., Dunbar, M.B., Alkemade, R., 2012. Synergies and trade-offs between ecosystem service supply, biodiversity, and habitat conservation status in Europe. Biological Conservation 155, 1–12. https://doi.org/10.1016/j.biocon.2012.06.016

Malek, Ž., Boerboom, L., 2015. Participatory Scenario Development to Address Potential Impacts of Land Use Change: An Example from the Italian Alps. Mountain Research and Development 35, 126–138. https://doi.org/10.1659/MRD-JOURNAL-D-14-00082.1

Mallampalli, V.R., Mavrommati, G., Thompson, J., Duveneck, M., Meyer, S., Ligmann-Zielinska, A., Druschke, C.G., Hychka, K., Kenney, M.A., Kok, K., Borsuk, M.E., 2016. Methods for translating narrative scenarios into quantitative assessments of land use change. Environmental Modelling & Software 82, 7–20. https://doi.org/10.1016/j.envsoft.2016.04.011

Manning, P., Plas, F. van der, Soliveres, S., Allan, E., Maestre, F.T., Mace, G., Whittingham, M.J., Fischer, M., 2018. Redefining ecosystem multifunctionality. Nature Ecology & Evolution 2, 427–436. https://doi.org/10.1038/s41559-017-0461-7

Martinez-Harms, M.J., Bryan, B.A., Figueroa, E., Pliscoff, P., Runting, R.K., Wilson, K.A., 2017. Scenarios for land use and ecosystem services under global change. Ecosystem Services 25, 56–68. https://doi.org/10.1016/j.ecoser.2017.03.021

Mastrangelo, M.E., Laterra, P., 2015. From biophysical to social-ecological trade-offs: Integrating biodiversity conservation and agricultural production in the Argentine Dry Chaco. Ecology and Society 20. https://doi.org/10.5751/ES-07186-200120
Metzger, M., Rounsevell, M., Van den Heiligenberg, H., Pérez-Soba, M., Soto Hardiman, P., 2010. How Personal Judgment Influences Scenario Development: an Example for Future Rural Development in Europe. Ecology and Society 15. https://doi.org/10.5751/ES-03305-150205
Metzger, M.J., Bunce, R.G.H., Jongman, R.H.G., Mücher, C.A., Watkins, J.W., 2005. A climatic stratification of the environment of Europe. Global Ecology and Biogeography 14, 549–563. https://doi.org/10.1111/j.1466-822X.2005.00190.x
Millenium Ecosystem Assessment, 2005. Ecosystems and human well-being: biodiversity synthesis. World Resources Institute, Washington, DC, USA.
Navarro, L., Pereira, H., 2012. Rewilding Abandoned Landscapes in Europe. Ecosystems 15, 900–912. https://doi.org/10.1007/s10021-012-9558-7
Nitsch, H., Rutz, C., Mehić, Ž., Hagemann, N., Holzkämper, A., Romero, M.N., Schönhart, M., van der Zanden, E., Willaarts, B., 2017. Policy analysis- report of work package 1 (TALE: Work package report D1.1).
O'Neill, B.C., Kriegler, E., Ebi, K.L., Kemp-Benedict, E., Riahi, K., Rothman, D.S., van Ruijven, B.J., van Vuuren, D.P., Birkmann, J., Kok, K., Levy, M., Solecki, W., 2015. The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. Global Environmental Change in Press. https://doi.org/10.1016/j.gloenvcha.2015.01.004
Phalan, B., Balmford, A., Green, R.E., Scharlemann, J.P.W., 2011a. Minimising the harm to biodiversity of producing more food globally. Food Policy 36, S62–S71. https://doi.org/10.1016/j.foodpol.2010.11.008
Phalan, B., Onial, M., Balmford, A., Green, R.E., 2011b. Reconciling Food Production and Biodiversity Conservation: Land Sharing and Land Sparing Compared. Science 333, 1289–1291. https://doi.org/10.1126/science.1208742
Phalan, B., 2018. What Have We Learned from the Land Sparing-sharing Model? Sustainability 10, 1760-1784. https://doi.org/10.3390/su10061760
Power, A.G., 2010. Ecosystem services and agriculture: tradeoffs and synergies. Philos. Trans. R. Soc. B-Biol. Sci. 365, 2959–2971. https://doi.org/10.1098/rstb.2010.0143
Quinn, J.E., Brandle, J.R., Johnson, R.J., 2012. The effects of land sparing and wildlife-friendly practices on grassland bird abundance within organic farmlands. Agriculture, Ecosystems and Environment 161, 10–16. https://doi.org/10.1016/j.agee.2012.07.021
Ramankutty, N., Rhemtulla, J., 2013. Land sparing or land sharing: Context dependent. Frontiers in Ecology and the Environment 11, 178. https://doi.org/10.1890/13.WB.009
Rounsevell, M.D.A., Reginster, I., Araújo, M.B., Carter, T.R., Dendoncker, N., Ewert, F., House, J.I., Kankaanpää, S., Leemans, R., Metzger, M.J., Schmit, C., Smith, P., Tuck, G., 2006. A coherent set of future land use change scenarios for Europe. Agriculture, Ecosystems & Environment 114, 57–68. https://doi.org/10.1016/j.agee.2005.11.027
Saxonian Ministry for the Environment and Agriculture, 2007. Richtlinie des Sächsischen Staatsministeriums für Umwelt und Landwirtschaft zur Förderung von flächenbezogenen Agrarumweltmaßnahmen und der ökologischen Waldmehrung im Freistaat Sachsen (Förderrichtlinie Agrarumweltmaßnahmen und Waldmehrung – RL AuW/2007).
Scariot, A., 2013. Land sparing or land sharing: The missing link. Frontiers in Ecology and the Environment 11, 177–178. https://doi.org/10.1890/13.WB.008
Schönhart, M., Schauppenlehner, T., Schmid, E., Muhar, A., 2011. Analysing the maintenance and establishment of orchard meadows at farm and landscape levels applying a spatially explicit integrated modelling approach. Journal of Environmental Planning and Management 54, 115–143. https://doi.org/10.1080/09640568.2010.502763
Schröter, D., Cramer, W., Leemans, R., Prentice, I.C., Araújo, M.B., Arnell, N.W., Bondeau, A., Bugmann, H., Carter, T.R., Gracia, C.A., Vega-Leinert, A.C. de la, Erhard, M., Ewert, F., Glendining, M., House, J.I., Kankaanpää, S., Klein, R.J.T., Lavorel, S., Lindner, M., Metzger,

M.J., Meyer, J., Mitchell, T.D., Reginster, I., Rounsevell, M., Sabaté, S., Sitch, S., Smith, B., Smith, J., Smith, P., Sykes, M.T., Thonicke, K., Thuiller, W., Tuck, G., Zaehle, S., Zierl, B., 2005. Ecosystem Service Supply and Vulnerability to Global Change in Europe. Science 310, 1333–1337. https://doi.org/10.1126/science.1115233

Swetnam, R.D., Fisher, B., Mbilinyi, B.P., Munishi, P.K.T., Willcock, S., Ricketts, T., Mwakalila, S., Balmford, A., Burgess, N.D., Marshall, A.R., Lewis, S.L., 2011. Mapping socio-economic scenarios of land cover change: A GIS method to enable ecosystem service modelling. Journal of Environmental Management 92, 563–574. https://doi.org/10.1016/j.jenvman.2010.09.007

Tscharntke, T., Clough, Y.., Wanger, T.C.. c, Jackson, L.., Motzke, I.. c, Perfecto, I.., Vandermeer, J.., Whitbread, A.., 2012a. Global food security, biodiversity conservation and the future of agricultural intensification. Biological Conservation 151, 53–59. https://doi.org/10.1016/j.biocon.2012.01.068

Tscharntke, T., Tylianakis, J.M., Rand, T.A., Didham, R.K., Fahrig, L., Batáry, P., Bengtsson, J., Clough, Y., Crist, T.O., Dormann, C.F., Ewers, R.M., Fründ, J., Holt, R.D., Holzschuh, A., Klein, A.M., Kleijn, D., Kremen, C., Landis, D.A., Laurance, W., Lindenmayer, D., Scherber, C., Sodhi, N., Steffan-Dewenter, I., Thies, C., Putten, V.D., H, W., Westphal, C., Tscharntke, Teja, Tylianakis, J.M., Rand, T.A., Didham, R.K., Fahrig, L., Batáry, P., Bengtsson, J., Clough, Y., Crist, T.O., Dormann, C.F., Ewers, R.M., Fründ, J., Holt, R.D., Holzschuh, A., Klein, A.M., Kleijn, D., Kremen, C., Landis, D.A., Laurance, W., Lindenmayer, D., Scherber, C., Sodhi, N., Steffan-Dewenter, I., Thies, C., van der Putten, W.H., Westphal, C., 2012b. Landscape moderation of biodiversity patterns and processes - eight hypotheses. Biological Reviews. https://doi.org/10.1111/j.1469-185X.2011.00216.x, 10.1111/j.1469-185X.2011.00216.x

van der Zanden, E.H., Cord, A., Hagemann, N., Holzkämper, A., Kaim, A., Schönhart, M., Strauch, M., Verburg, P.H., Volk, M., Willaarts, B., 2016. Deliverarble 5.1: Systematic assessment of case study representativeness (TALE project report).

Verkerk, P.J., Lindner, M., Pérez-Soba, M., Paterson, J.S., Helming, J., Verburg, P.H., Kuemmerle, T., Lotze-Campen, H., Moiseyev, A., Müller, D., Popp, A., Schulp, C.J.E., Stürck, J., Tabeau, A., Wolfslehner, B., Zanden, E.H. van der, 2018. Identifying pathways to visions of future land use in Europe. Reg Environ Change 18, 817–830. https://doi.org/10.1007/s10113-016-1055-7

von Wehrden, H., Abson, D.J., Beckmann, M., Cord, A.F., Klotz, S., Seppelt, R., 2014. Realigning the land-sharing/land-sparing debate to match conservation needs: Considering diversity scales and land-use history. Landscape Ecology 29, 941–948. https://doi.org/10.1007/s10980-014-0038-7

Wardropper, C., Gillon, S., Mase, A., McKinney, E., Carpenter, S.R., Rissman, A.R., 2016. Local Perspectives and Global Archetypes in Scenario Development. Ecology and Society 21, 12. https://doi.org/10.5751/ES-08384-210212

Westerink, J., Jongeneel, R., Polman, N., Prager, K., Franks, J., Dupraz, P., Mettepenningen, E., 2017. Collaborative governance arrangements to deliver spatially coordinated agri-environmental management. Land Use Policy 69, 176–192. https://doi.org/10.1016/j.landusepol.2017.09.002

Wright, H.L., Lake, I.R., Dolman, P.M., 2012. Low-impact agriculture requires urgent attention not greater caution: Response to Phalan and colleagues. Conservation Letters 5, 325–326. https://doi.org/10.1111/j.1755-263X.2012.00247.x

Zurek, M.B., Henrichs, T., 2007. Linking scenarios across geographical scales in international environmental assessments. Technological Forecasting and Social Change 74, 1282–1295. https://doi.org/10.1016/j.techfore.2006.11.005