Chapter 8
Innovations for Sustainable Land Management—A Comparative Case Study

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Abstract There continues to be a poor understanding of how transformation and socio-technological change in the specific field of sustainable land use and management can be effectively governed and supported. The aim of this article is to contribute to this knowledge gap by presenting the findings from a comparative case study of nine local innovation projects that sought solutions for sustainable land management (SLM). For each of the nine projects, we examined the (i) problem definitions and framings, (ii) the type and degree of innovation, (iii) the different approaches taken to manage innovation processes, and (iv) the leverage points of these solutions in the governance system of SLM. The results show that SLM innovations start from diverse problem framings and emerge from distinct action fields. We found a broad variety of innovation types following distinct solution strategies that can be clustered into (i) multiple land use, (ii) knowledge-based decision support tools, (iii) co-management approaches, and (iv) new organisations and institutions. All nine projects applied multi-actor approaches to facilitate reflexive processes of social learning and cognitive reframing by embedding experimental innovation management approaches such as real-world laboratories (thus optimising the solution) into larger transdisciplinary and participatory processes (to adjust to societal discourses and normative orientations).

Keywords Sustainability innovation · Transdisciplinary research · Governance of land

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8.1 Sustainable Land Management—A Normative Orientation for Transformation

Land is an essential but limited "resource" to humans. Demand for land and land-based goods is increasing, and will continue to increase in the future due to a growing world population, economic growth, the energy transition, changes in consumption patterns, and, not least, climate change. As a result, it is assumed that there will be greater land use competition and more environmental degradation in the future (Haberl et al. 2014; Niewöhner et al. 2016).

Land has therefore become a key issue of sustainable development, since land use causes many sustainability problems. In the search for sustainable and socially responsible solutions that take into account complex interactions between different demands, associated actors and their (often conflicting) interests, perceptions and values, many scientists increasingly promote and discuss the concept of sustainable land management (SLM).[1]

Although SLM is not a clearly defined term, there are some common features that can be summarised as follows: SLM provides a normative orientation for policymaking and management; it takes a holistic systems perspective and addresses complex socio-ecological interactions and dynamics. SLM also takes into account multi-level and cross-sectoral approaches that stress social learning, experimentation, negotiation and the harmonisation of different goals; SLM involves multiple actor groups (e.g. Hurni 2000; Schwilch et al. 2012; Weith et al. 2013; Fritz-Vietta et al. 2017; Nölting and Mann 2018).

In general, SLM can be regarded as a concept of change and transformation building on the idea of adaptive resource co-management (see Armitage et al. 2009). It aims to achieve "*a change in understanding that goes beyond the individual to become situated within wider social units or communities of practice*" through social interactions between actors within social networks (Reed et al. 2010). In this context, the role of transdisciplinarity is highlighted by several authors (e.g. Hurni 2000; Nölting and Mann 2018).

However, beyond underlining the importance of transdisciplinarity, there is an "apparent lack of a practical, structured (yet flexible) methodology for fostering SLM in diverse contexts" (Schwilch et al. 2012). Thus, it is an open question how transformation and socio-technical change towards SLM can be effectively designed and supported.

The aim of transdisciplinary (research) processes (TDR) is to provide socially robust orientation for sustainable solutions. However, the initiation and management of innovation processes plays a central role in developing, testing and implementing such solutions. And yet very few studies explicitly address SLM innovations. A lot of scholarly work has been conducted on innovation processes in general, but it can be

[1] A literature review shows that there has been an increase in the number of publications on SLM over the past decade. A "scopus" search for the term "sustainable land management" generated 168 articles in April 2019.

assumed that SLM innovations differ considerably from the "usual" types of innovation. While market-based (business) innovations are generated against the backdrop of the interests of individual economic actors who often accept the externalisation of costs, SLM innovations pursue a general interest and the idea of common goods in a bid to avoid the externalisation of costs.

Thus, SLM innovations are based on a different set of push factors and are often dependent on policy-driven innovation systems and the funding of collaborative actors from science and practice (from different administrative levels and sectors).

The aim of this article is to identify specifics of SLM innovations and associated innovation processes by undertaking a comparative case study of nine research projects[2] conducted within the German funding programme entitled "Innovation Groups for Sustainable Land Management". We argue that understanding these processes is highly relevant in the bid to improve the steering and design of effective innovation and transformation processes for SLM.

8.2 The "Sustainable Land Management" Innovation System

Knowledge is considered a central resource in innovation processes (e.g. Howells 2002; Thornhill 2006); therefore, attention was increasingly focused on exchange and cooperation between actors and organisations for developing and disseminating innovations. This idea can be found in the discourse on "innovation systems", where innovations arise as a result of the interplay between different levels of an institutional structure (Edquist 1997). In this context, the meaning of "regional innovation systems" (RIS) was increasingly discussed. RIS are "typically understood to be a set of interacting private and public interests, formal institutions, and other organizations that function according to organizational and institutional arrangements and relationships conducive to the generation, use, and dissemination of knowledge" (Doloreux and Parto 2005, p. 134). So far, the concept of regional innovation systems has been discussed as a concept of spatial positioning and clustering (national/regional; increasing competitiveness of regions; regional development).

By offering various support measures to promote research and innovations in SLM, national innovation policy seeks to initiate regional innovation systems via innovation policy programmes. In Germany, for example, the Federal Ministry of Education and Research (BMBF) launched a range of consecutive funding programmes[3] dealing thematically with the integrated consideration of different uses

[2] All nine research projects were accompanied by a scientific coordinating research project over a period of five years. As part of this scientific coordinating project, the authors had very good access to the documents and team members of all nine projects. The results of the comparative case study are based on the analysis of qualitative interviews with coordinating scientists, and of documents, participatory observations during numerous events (workshops, conferences), and informal talks.

[3] https://www.fona.de/en/topics/land-management.php.

of land and natural resources, their interactions, and the corresponding development of solutions: REFINA (2006–2012),[4] Sustainable Land Management (2010–2016), Innovation Groups for Sustainable Land Management (2014–2020)[5] and Stadt-Land-Plus (2017–2026).[6] This funding agency regularly issues thematic calls—similar to EU funding structures—and sets important framework conditions for research (e.g. action field of research, disciplinary focus). Within the FONA framework programme (Research for Sustainable Development), the BMBF also encourages and often requires research projects to pursue research modes based on societally relevant research goals (Newig et al. 2019). The term "Sustainable Land Management" is thus largely supported (top-down) by research policy and predefined (science plays an advisory role but with a control component), but at the same time influenced (bottom-up) by the concrete thematic design of each research project.

Looking at these calls for tender and the available literature on RIS reveals that the "Sustainable Land Management innovation system" differs from the RIS concept in that it is heavily dependent on external funding and is only an innovation system for a certain period of time (demolition after the end of the eligibility period). Thus one of the core challenges is to achieve the continuity and transfer of processes to practice beyond the project duration. At the same time, there are a number of similarities with the RIS concept, such as.

- the importance of knowledge and the concept of the learning region, individual and collective learning, exchange of knowledge (e.g. Blättel-Mink 2006)
- cooperation between different actors: companies, politics, research, administration and a combination of public and private interests (Doloreux and Parto 2005)
- the regional dimension of innovation processes and development; the region as the locus of innovation
- the policy focus: systematic support of regional development (capacity building in regions, local comparative advantages, etc.).

All SLM funding programmes[7] are framed by political strategies of the German Federal Government.[8] They promote the development and testing of innovative concepts and strategies as well as "knowledge bases, technologies, instruments and system solutions" to (1) "reduce land consumption", (2) "protect livelihoods", and (3) mitigate "increasing competition for land and natural resources". The declared aim is to protect nature and the climate; secure energy and food supplies; promote health, social justice and the balancing of interests; and assure a high level of life

[4] https://www.fona.de/en/measures/funding-measures/archive/research-for-the-reduction-of-land-consumption-refina.php.

[5] https://www.fona.de/en/measures/funding-measures/innovation-groups-for-sustainable-land-management-fuer-ein-nachhaltiges-landmanagement_copy.php.

[6] https://www.fona.de/en/measures/funding-measures/city-countryside-plus.php.

[7] The results are based on an analysis of the call for proposals of REFINA, SLM, IG SLM and Stadt-Land-Plus.

[8] e.g. The National Sustainable Development Strategy, the German Hightech Strategy, and specified by the FONA framework (research for sustainable development).

quality. As a level of consideration, regions are regarded as a particularly promising spatial intervention level (e.g. "sustainable development of regions", regional circular economy", "regional value chains"). Emphasis is also placed on the central role of holistic systems approaches, reflected by the demand for "system solutions", which consider the "system context", complex interactions and urban–rural linkages.

In sum, SLM is regarded as a "key issue" and a highly "complex area of activities" that integrates different sectors, demands and interests such as water, soil, biodiversity, regional value creation, urban and rural areas, and others. Consequently, an interdisciplinary, cross-sectoral and transdisciplinary collaboration between actors from practice (politics, administration, economy and civil society) and science was mandatory.

8.3 Analysis of Innovations in Sustainable Land Management

We sought adequate frameworks and theoretical models to identify the specifics of SLM innovations, to better understand the underlying innovation processes, and to structure our study. Despite a thorough review, we found no conceptual framework with a consistent explanation or guidance for the very diverse processes and projects that we accompanied.

Not only does the literature distinguish between different types of innovation (technical, social and process innovations) that require different management approaches, innovation processes are also embedded in very complex contexts. Due to this complexity, there is often doubt as to the extent to which such complex processes can be controlled and purposefully managed (e.g. Sauer 1999; Kristof 2010).

However, it can also be stated that change and innovation processes are more than random events that do not happen out of nothing, but that can and need to be stimulated. In this context, many authors emphasised the role of conditions and innovation contexts that can be managed to support innovations. Particularly concerning sustainability innovations, the "multi-impulse hypothesis" has increasingly come to the fore (e.g. Kramer 2010). Here, the foci can be very diverse, as demonstrated by a collection of theories about socio-technical change with "the most explanatory power" or applicability by Sovacool and Hess (2017). The authors interviewed 35 experts from different disciplinary backgrounds and found 96 distinct theories. The most frequently mentioned theories were the socio-technological transition approach (after Geels 2002, Geels and Schot 2007), social practice theory (Shove et al. 2012), discourse theory, social construction of technology, and sociotechnical imaginations. Sovacool and Hess (ibid.) were able to show that most theories focus on the categories (i) agency, (ii) structure, (iii) meaning, (iv) relations, and (v) norms.

For our analysis,[9] we followed these main categories and chose a rather research pragmatic approach, adopting the suggestion by Heideloff and Radel (1998) to focus on a higher degree of abstraction. Thus, we focused on reasonings and meanings by considering **problem framings and definitions** and normative orientations of the desired **solutions** as well as the underlying **strategies**. We additionally applied established categories from the innovation literature, such as the **type of innovation** and **innovation degree** (e.g. Hauschildt et al. 2016; Kasmire et al. 2012; Baregheh et al. 2009) to determine whether there are any specific properties relevant to SLM innovations. We also sought to determine the **main barriers** to the successful implementation and distribution of these innovations, and how attempts were made to manage and control **innovation processes**.

8.4 Case Study: The German Funding Programme "Innovation Groups for Sustainable Land Management"

As described above, the "Innovation Groups for Sustainable Land Management" (IG) funding programme (2014–2020) is part of a land-focused funding line initiated by the BMBF. In contrast to the preceding programme "Sustainable Land Management" (2010–2016), the IG programme focuses on developing systemic solutions to complex real-world issues, analysing innovation conditions, and building up capacities and competences among the practice actors and scientists involved in order to drive innovative solutions that have been outlined and defined during the application process.

In total, nine joint research projects (the "Innovation Groups", or IGs) were funded over a period of five years (2014–2019) with Germany as the geographical focus of application. The IGs differed in size, actor composition (i.e. academic disciplinary background, practitioners' background) and research questions. In terms of topics, the IGs can be clustered in at least four different application fields: (1) research on regional energy transition in the context of land consumption and land competition; (2) research on multiple or diversified land use options on the same plot of land; (3) research on cultural landscape development; and (4) research on interlinkages between urban and rural spaces. Numerous IGs conducted their research activities in more than one cluster, e.g. by combining Clusters 3 and 4. Table 8.1 provides more detailed information on the projects under investigation, along with various characteristics.

[9] Our findings result from accompanying the projects over a period of five years. They are based on the analysis of project proposals and websites, participatory observations during events, informal talks and semi-structured interviews with coordinating scientists.

Table 8.1 Overview of the "Innovation Groups" under investigation

Project	Problem framing and definition	Solution approach/innovation	Innovation process design/methodology	Degree of innovation	Type of innovation	Main barriers
APV-Resola	Growing demand for renewable energy; growing competition for (agrarian) land resources	Development of agrophotovoltaic test sites (APV) that integrate solar power generation into agrarian (crop) production	Living Lab (according to project proposal)	First conceptual ideas in the 1980s; new in-situ reaIisation of APV	Technological, procedural	Legal framework conditions; entrepreneurial risks; lack of social acceptance at the local level; loss of area payment grants by CAP
AUFWERTEN	Negative environmental effects on agrarian land resources (degradation, loss of biodiversity) under conditions of growing productivity demands on land	Agro-forestry systems—cultivation of agricultural woods and field crops on the same parcel of land	"Trial and error" (lab character, open innovation techniques, multidimensional)	Realisation on test sites since the 1990s	Technological, procedural	Legal framework conditions, disadvantages in CAP area payments, lack of infrastructure along the value chain
EnAHRgie	Land use competition and conflicts in the development of "energy transition landscapes"	Integrated regional energy concept, tool development, policy development	Participatory process with regional (organised) stakeholders backed up by scientific evidence	Novelty in the regional context	Social innovation (action-guiding concept)	General inertia; lack of acceptance of certain technologies

(continued)

Table 8.1 (continued)

Project	Problem framing and definition	Solution approach/innovation	Innovation process design/methodology	Degree of innovation	Type of innovation	Main barriers
Ginkoo (two regional case studies)	(A) Loss of a traditional cultural landscape (B) Ethically questionable poultry production	(A) Collaborative landscape management (B) dual purpose chicken	Real-World Lab	Pre-existing "niche" solutions (A) 30 yrs. of regional activities (B) "Re-innovated" technique	(A) Technological (hay), institutional innovation (B) Social innovations	Legal and economic framework conditions, stakeholder conflicts
INOLA	Land use competition and conflicts in the development of "energy transition landscapes"	Tools for participatory process design; organisation development ("regional citizens foundation" as the lead organisation of the change process)	Participatory process with stakeholders and citizens, backed up by scientific evidence	Novelty in the regional context	Social innovation (institutional, procedural)	Financing, inertia of institutions, acceptance issues among citizens
REGIO-BRANDING	Marginalised rural areas in metropolitan regions	Development of a regional brand by means of a collaborative, bottom-up research process	Participatory research design, transdisciplinarity, CBPAR	New approach (to regional marketing)	Social innovation, institutional innovation	Continuation of activities requires commitment by regional decision-makers, cross-sectoral collaboration

(continued)

Table 8.1 (continued)

Project	Problem framing and definition	Solution approach/innovation	Innovation process design/methodology	Degree of innovation	Type of innovation	Main barriers
Render	Land use competition and conflicts in the development of "energy transition landscapes"	Application of a regional, inter-municipal energy transition concept	Transdisciplinary learning and application process	Novelty in the regional context	Social innovation, procedural innovation	Political will, inertia of institutions
Stadt PARTHE land	Growing land use competition in peri-urban regions with changing cultural landscapes	Concept for cultural landscape management	Incremental management approach ("muddling through")	New approach (to cultural landscape management)	Integration of technological and social innovations	Hosting institution, financing, acceptance
Urban–Rural Solutions	Demographic change challenges the existing provision of public services in rural regions	New instruments/options as a result of regional urban–rural co-operation	Design thinking approach	New for the specific application field	Social and technological innovations	Continuation of activities requires commitment by decision-makers, cross-sectoral collaboration, multi-level governance, local/regional

8.4.1 Problem Definition of Projects and Societal Pressure for Action

One central and frequently described success factor for innovation processes is the consideration of concrete application needs raised by prospective appliers. As a consequence, the question of how the problem is defined at the beginning plays a decisive role for the design and development of solutions (e.g. Enkel 2009; de Jong et al. 2016).

The majority of projects used the narrative of "increasing land use competition" in order to prove the relevance of their research project and the desired solutions. Here, the projects align their narrative with that of the funding agency, and address the problem definition described in the announcement.

Applicants additionally formulate five other problem areas and fields of action: (i) the loss of cultural landscapes, (ii) environmental degradation, (iii) increasing land use conflicts, (iv) disparities between urban and rural areas and the challenges of demographic change, and (v) the challenges of spatial justice. Thus, the projects reflect a rather wide range of fields of action and current problems, and illustrate the diversity of challenges in SLM. At the same time, it must be acknowledged that the projects represent only some of the current land use challenges. Thus, other urgent issues such as landscape fragmentation, climate change impacts, urban sprawl and contamination remained unconsidered (see EEA 2019).

One striking aspect is that many of the nine research projects focus on the challenge of changing the energy system (APV-Resola, AUFWERTEN, INOLA, render, EnAHRgie). This is not surprising, since the spatial dimension of renewable energy production and distribution in Germany is decisive (see Meyer and Priefe 2015). There is considerable pressure to act and transform the energy supply system, which is discussed extensively by many societal actors.

8.4.2 Solution Strategies and Types of Innovation

It is striking that the concept of innovation, which is traditionally often equated with the understanding of technological innovation, is significantly expanded in the context of SLM. While there are still projects that focus on new technologies and processes (such as agroforestry systems and agrophotovoltaic plants), most projects place a strong emphasis on "social innovations".

In the literature, there are different interpretative patterns of the term "social innovation" and corresponding heterogeneous theoretical approaches. In accordance with others (e.g. Taylor 1970; Brooks 1982; Schubert 2016), we consider the term as an extension of the notion of technological innovation and define "social innovation" as "new" practices that provide alternative solutions to persisting problems (Zapf 1989), driven by specific actors in specific operating contexts (Rogers 2003; Howaldt and Schwarz 2010).

Such "new" practices were the aim of many of the nine projects under investigation. These practices include new participation concepts, decision support tools, the initiation and strengthening of new collaborations and networks, and new organisations.

It emerges that the solution approaches adopted by the nine projects can be grouped into four clusters that follow different strategies:

1. ***Multiple land use*** (Example: agroforestry systems, agrophotovoltaic plants)
   These projects primarily focused on the development of technological innovations that follow the strategy of "multiple land use" to mitigate land use competition. In contrast to concept of "multifunctional land use", which advocates heterogeneity at the landscape level (see Mander et al. 2007), "multiple land use" means that one land plot is used simultaneously for two purposes such as agrophotovoltaic plants that are installed above crops, generating two harvests: the harvest of solar power and of crops (see Photo 8.1). The innovation revolves around a new technology that was developed in strong interaction with farmers on a specific plot, applying an experimental living-lab approach.
   A similar research setting was applied by the AUFWERTEN innovation group, which investigated the applicability of agroforestry systems to "regular" farming practices. As in the first example, a farmer provided test sites where the applicability of the innovation was tested in a real-world laboratory setting. In contrast to the agrophotovoltaic test site, the agroforestry project allowed for a rather open innovation research approach because the installation of woody structures on

Photo 8.1 Multiple land use by an agrophotovoltaic plant that enables solar power and crops to be harvested simultaneously from one plot (*source* ISE Fraunhofer)

arable land requires little monetary investment and, thus allows experimentation and many variations. In contrast, the APV plant was rather cost-intensive. Thus, the margin for processual adaption and innovation was narrow.

2. **Improvement of decision-makers' knowledge base** (example: integrated energy concepts)
   Several projects developed instruments to help decision-makers make well-informed and justified decisions when dealing with complex situations where stakeholders often have opposing views and where trade-offs between different societal goals are prevalent. This included integrated and action-oriented concepts for municipal administrations (usually in the context of energy transformation), decision support systems, and associated tools and instruments (EnAHRgie, render and ginkoo).
3. **Co-management approaches** (example: collaborative landscape management)
   Another strategy was to establish new alliances, networks and collaborations for pooling scarce resources, facilitating mutual knowledge exchange and social learning, and to coordinate collective actions. As an example, in one project, where the loss of the traditional cultural landscape was defined as a problem shared by all of the actors involved, the idea of collaborative landscape management was advocated as a promising solution (Zscheischler et al. 2019). In this case, several partial solutions (also technological innovations) were co-designed and co-developed by actors from different sectors such as farmers, tourism providers and nature conservation. These solutions were complemented by the idea of an integrated management concept that includes new forms of coordination, new co-operation and new networks on a community level. The process combined a real-word lab approach (for co-designing and testing several partial solutions) with a transdisciplinary process. This combination facilitated a joint problem framing, the harmonisation of actors' different visions and conflicts by means of a consensual discourse, the initiation of social learning processes, and the strengthening of actors' relationships (Fig. 8.1).
4. **New Organisations and Institutions**
   Another type of outcome and innovation was the development and construction of new organisations and institutions that took responsibilities and (in some cases) mandates to manage or co-ordinate land resources. Here, a general approach was to install an administrative or co-ordination position, which we call the "land use manager".
   These managers worked at the interface between governance and government, as well as between different land use sectors (vertical and horizontal structures). From an organisational point of view, the implementation of "land use managers" can be seen as an adaptation of the current German practice of administrative units that work at the municipal or regional level based on cross-sectoral tasks, defined by policy demands. As an example, "climate protection managers" have been installed in recent decades to accompany the implementation of climate targets set by the government (at different administrative levels). Climate protection managers work horizontally (cross-sectorally) as well as vertically (between hierarchical levels) within the administration. They also perform communication

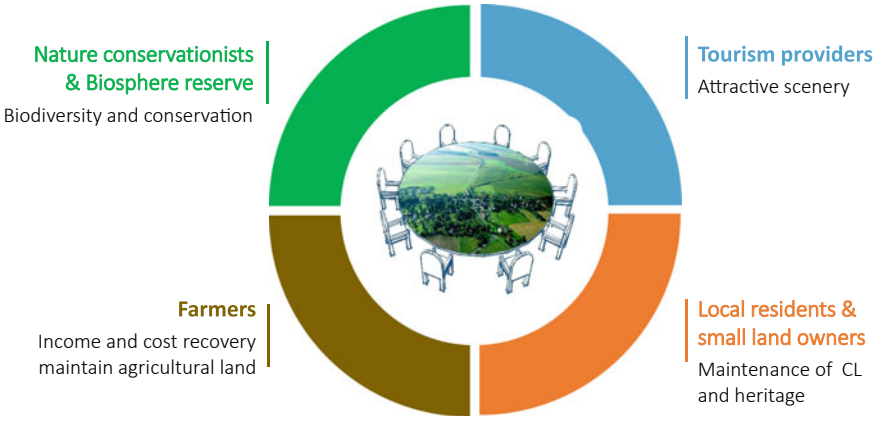

Fig. 8.1 Collaborative landscape management integrates different interests and pools resources from actors of different sectors to manage and develop a traditional cultural landscape including the typical attractive scenery, cultural heritage, biodiversity and cost recovery (own source)

tasks involving social learning, information and acceptance by the populace. Although there is also a concrete political goal in Germany to reduce excessive land consumption, there is not yet a corresponding administrative position that addresses "land management" as a cross-sectional issue. Therefore, the projects filled that "blind spot", albeit in different ways. The INOLA project, for example, tasks a citizens' foundation with pursuing the goal of achieving the regional energy transition. The foundation was initiated by citizenship interests and political will, and was eventually given a political mandate by its founding rural districts (Landkreise).

Other projects established citizens' initiatives to coordinate actions of different actor groups towards the common goal/interest of cultural landscape management.

8.4.3 Steering Innovation Processes

All projects were invited by the application call to implement a transdisciplinary research approach that brings together different actors from science and practice, integrating their perspectives and interests. This requirement is based on the assumption that the process design and development of sustainability innovations plays an important role in the transformation towards the socially responsible use of land and natural resources.

Innovations in integrated sustainable land management (or sustainability innovations) also differ from the more classic (product, process, marketing or organisational) innovations studied in economics. Besides addressing economic exploitation structures, they also seek, among other things, to achieve the multifunctionality of agrarian

landscapes. Sustainability innovations are thus often associated with competitive disadvantages (Nidumolu et al. 2015). In addition, in order to be able to develop and establish themselves, sustainability innovations usually require "second–order" innovations; they "challenge" conventional paradigms, routines and institutions (Knickel et al. 2009), and eventually reconfigure regimes (Geels and Schot 2007) where technical and economic drivers have proven inadequate (Hegger et al. 2007). Moreover, the development and enforcement (including adoption and impact) of innovations is seen as a social process (Currie et al. 2005) and as a result of co-evolutionary development and learning processes that involve different stakeholder groups and bring together knowledge resources (e.g. Ingram et al. 2015; Kemp et al. 2009; Schot and Geels 2008).

Most of the projects then addressed these conceptual considerations by designing innovation processes with the participation of various stakeholder groups. Different approaches were used in the nine research projects (see Table 8.1). Examples include the "real-world" or "living lab" approach, the "open innovation" concept, the method of "design thinking". Transdisciplinary processes were also conducted, as well as very incremental management approaches that can be described as "muddling through". Combinations of several approaches, such as a transdisciplinary learning process with a real-world lab approach (see also Rogga et al. 2018) were often observed.

Such combinations appear to be pertinent: while transdisciplinary processes enable the joint definition of problems in the consensual discourse, the integration of different stakeholder perspectives, the elaboration of objectives and the identification of suitable innovations, the other methods and approaches enable these solutions and the corresponding transformation knowledge to be tested and experimented with.

8.4.4 Leverage Points in the Governance System of Land (Use)

As stated above, we consider SLM to be a concept of change and transformation. In this context, the term "management" refers to activities and interventions that seek to bring about a shift towards more sustainable land use. Land (use), however, is a highly regulated subject/field with several intervention levels, as shown in Fig. 8.2 (adapted after Hurni 1997).

With regard to the nine projects under investigation, we found that most projects comprised interventions and developed innovations at levels between the land plot (e.g. technological innovations such as agrophotovoltaic plants, agroforestry systems) and the community (e.g. collaborative landscape management, integrated spatial energy concepts). However, we also found that the projects coordinators mentioned legal conditions as main barriers to innovation processes. Thus, it may be worthwhile considering TDR projects that also involve actors from higher intervention levels in the future.

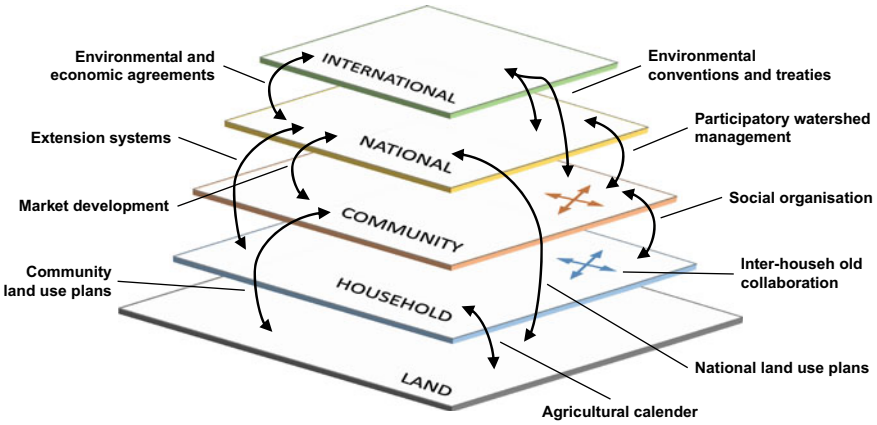

Fig. 8.2 Intervention levels for sustainable land management (adapted after Hurni 1997, 2000)

8.5 Discussion and Conclusion: Three Theses on the Specifics of SLM Innovations

The aim of this article was to identify the specifics of SLM innovations and the underlying innovation processes (see Table 8.1). The comparative analysis of nine transdisciplinary research projects led us to formulate three theses on the specifics of SLM innovations, which are presented and discussed below.

Thesis #1
SLM is a New and Complementary Form of Governance and Normative Orientation

A closer look at the solutions developed in the nine projects under examination shows that SLM and the underlying innovations can be regarded as a strategy to counterbalance the disadvantages and shortcomings of land use that is managed sectorally and organised by the government. Thus, we consider SLM to be a "new" and complementary form of governance that focuses on innovation processes and follows an adaptive co-management approach (Armitage et al. 2009) involving science and practice to iteratively design and test solutions for the more sustainable use of natural resources and land.

This thesis is supported by the types of innovation evolving from the nine projects under examination. Although two of the nine projects focused on technological innovations (such as agroforestry systems and agrophotovoltaic plants), most of the projects centred around social innovations. These innovations included new collaborations and networks between actors from different sectors; the development of new institutions such as the establishment of a coordinating authority (e.g.,"land use managers") or of tools for supporting well-informed and justified decisions in situations of great uncertainty and complexity.

Although other scholars have highlighted the integrative nature of SLM (e.g. Nölting and Mann 2018; Wang and Aenis 2019), comprising the components of technology, policy and land use planning (Hurni 2000), the interaction of different types of innovation and the specific role played by social innovations in SLM has not yet been considered. We argue that taking a deeper look at these conditions would enhance our understanding of sustainability transformations.

Thesis #2
SLM Innovation Processes Follow a Multiple-Objective Strategy and Combine Transdisciplinary Processes with Innovation Management Approaches

Most projects followed a two-fold approach and combined a number of partial solutions (local niche innovations) with a "regional" integration concept. As a consequence, transdisciplinary processes were frequently combined with other innovation management approaches such as real-world labs or the open innovation approach. Thus, transdisciplinary processes were applied to integrate different types of knowledge and perspectives from a wider sphere of actor groups, especially when framing and jointly defining the problem or initial situation (systems knowledge), but also when supporting the development of visions and targeted sustainable futures (target knowledge). This corresponds with the ideas of many scholars who regard transdisciplinarity as a valuable approach to provide "socially robust orientation" for sustainable development (Nowotny et al. 2001). However, it can be argued that complementary approaches that allow the co-design and testing of innovations (transformative knowledge) within this jointly defined framework are required for the development of concrete solutions and interventions.

The combination of transdisciplinary processes with real-world lab approaches has already been observed in other studies (Rogga et al. 2018). It has been shown that embedding the innovation process in a broader transdisciplinary discourse is conductive to estimating unintended effects more effectively, and reducing ethical concerns, but also to considering critical questions of legitimacy.

Thesis #3
Innovations for Sustainable Land Management Are Neither Disruptive nor Radical

The literature on innovation studies often differentiates between incremental and disruptive or "radical" innovations. This differentiation refers to how an innovation influences and challenges the existing system and stimulates follow-up innovations.

Accordingly, radical innovations are innovations that have a "high degree of novelty, being totally or substantially new" and a "profound effect on future development, establishing whole new fields of study" as well as new technological systems, "making dominant rival technologies or processes obsolete" (Kasmire et al. 2012). These innovations are frequently associated with eureka moments, ingenious ideas and flashes of inspiration (e.g. van de Poel 2003).

In contrast, there are "incremental innovations" that are far less ground-breaking, new and original, and more likely to result in changes and modifications in the form of incremental improvements to existing innovations and technological systems.

This differentiation according to the novelty and impact of innovations appears to be rather questionable, because assessing the novelty of an innovation is a very subjective and vague matter. Kasmire et al. (2012, p. 348) argue: "when examined critically, the birth process of many "radical" innovations reveals only logical, even obvious, small steps with no "eureka" moments".

With regard to the projects examined here, it emerged that SLM innovations were neither "sensationally new" nor radical or disruptive. Instead, they can be considered as incremental adaptations towards new normative objectives or paradigms such as the Sustainable Development Goals (SDGs) or growing awareness of the importance of a systems perspective. SLM innovations in the nine projects under investigation were often locally tailored solutions that were mainly based on existing ideas, and were now being implemented.

The extent to which the concept of "radical" innovations applies to SLM innovations is questionable because they often revolve around social innovations such as new forms of coordination and collaboration. However, the concept of "radical" innovations was derived from and is related to the retrospective study of technological innovations (ibid.). Nonetheless, the concept of "radical" innovations seems hardly applicable to SLM innovations, also with regard to the impact of such innovations.

Although some of the projects also focused on technical/product innovations (e.g. hay ovens, biomillers, agrophotovoltaic systems, agroforestry systems), these innovations were closely tied to the well-regulated resource of "land".

For example, agroforestry systems with short-rotation wood strips for energy wood production have been researched and developed in Germany for over 25 years. However, the implementation and dissemination of such systems in practice has so far failed due to the legal framework. In this case, minimal changes (also in terms of subsidy backdrops) may cause considerable land use changes and, in retrospect, appear to be "radical". However, it is unlikely that agroforestry systems will completely replace other agricultural systems. It is more likely that such systems will complement other systems, where appropriate.

The strict regulation of land is not only a strong barrier to SLM innovation. It is very likely that it will influence the innovation process from the very beginning, excluding legally unworkable solutions from the outset. From a critical point of view, the innovations developed within the nine projects under examination are mainly based on the existing system. The extent to which these innovations challenge current regime structures is an open question.

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