European long-term ecosystem, critical zone and socio-ecological systems research infrastructure PLUS

Report on socio-ecological analyses of stakeholder-defined local and regional environmental challenges

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List of abbreviations

ABM	Agent-based model
CS	Case study
eLTER	European Long Term Ecological Research
eLTSER	European Long Term Socio-Ecological Research
ESFRI	European Strategy Forum on Research Infrastructures
FOM	Farm Optimization Model
PPD	Press-Pulse Dynamics
QDM	Qualitative Data Management
RA	Remote Access
RI	Research Infrastructure
SC	Science Case
SES	Socio-ecological systems
SNA	Social Network Analysis
SO	Standard Observation
TA	Trans-national Access
VA	Virtual Access
WAILS	Whole system Approach for In-situ research on Life Supporting Systems in the anthropocene

Summary

The primary objective of this deliverable is to summarize contributions of Task 8.4 to connected working groups in eLTER PLUS and derive conclusions from the Science Case to inform development of eLTER RI, in particular the SO framework, development of data products and services, eLTSER platform design and management, as well as WAILS. On the one hand aim of Task 8.4. is 'scientific' in terms of implementing a socio-ecological science case to test the existing eLTER RI in designated LTSER platforms, and on the other hand 'operational' in terms of deriving inputs from this case study for RI development. To being able to address both objectives consistently, we adopted a research strategy that is conceptually as well as practically characterized by the systematic integration of top-down and bottom-up approaches. The top-down approach, on the one hand, addresses the identification and normative definition of socio-ecological research themes, their data and service requirements as well as potential availability gaps and access restrictions. The bottom-up approach, on the other hand, consists of performing a functional test of the running RI's products and services at the eLTSER platform-level. Combining the selected approaches then allowed us to generate a range of diverse scientific and operational insights for RI development. In this deliverable we derive conclusions and critically discuss socio-ecological data requirements, exemplary workflows and data products associated with socio-ecological research, striving towards the WAILS approach, necessity and enabling conditions for transdisciplinary science and qualitative data management, recommendations for platform management and staff qualification as well as feedback on relevant data tools.

1 Introduction and project context

The eLTER PLUS project is an advanced community's project that – as stated in the proposal - drives the development of the eLTER community toward the establishment of a formal RI. eLTER PLUS aims to develop and disseminate novel methods for integrating ecosystem, critical zone, and socio-ecological research at pan-European, in situ research sites to provide national and European decision makers, natural resource managers and land use planners with quality-controlled information and tools for detecting the long-term efficiency of policies.

Main objectives of eLTER PLUS are to execute a performance test of the emerging eLTER RI, advance inter- and transdisciplinary research, facilitate access to eLTER sites and platforms as well as to their current and legacy data and services. This approach includes, among others, development of the RI's standard observation (SO) framework; workflows, data products and services; site and platform design and management; as well as enhancing community and capacity building and providing key input to the eLTER PPP project and the eLTER ESFRI process. The analyses and recommendations described in this report should be viewed in this context.

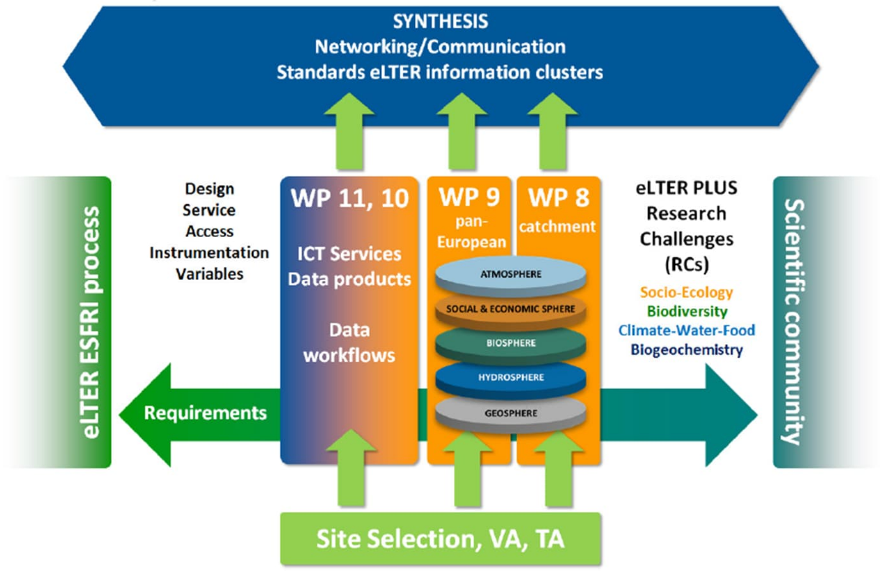

Figure 1: The core concept of eLTER PLUS. (Source: eLTER PLUS Proposal, 2019)

Figure 1 shows the core concept of eLTER PLUS. In the center, WPs 8 and 9 address the different system layers (ranging from geosphere to atmosphere) covered by eLTSER sites and platforms. From these system layers, four Research Challenges (RCs) are derived. The RCs are implemented by WP 8 at the site scale and WP 9 at the catchment-to-continental scale in the form of exemplary thematic Case Studies (CSs) carried out by the relevant scientific communities. Cross-theme collaboration between these communities addresses the eLTER Whole System Approach. WPs 10 and 11 translate user requirements and research products across themes into tool and data product specifications and perform service/tools piloting and implementation. Strategic site selection is based on the existing eLTER site pool for site and data usage in the eight CSs. The CSs also implement and test virtual access (VA), trans-national access (TA) and remote access (RA) to the sites' and platforms' data and services. The eLTER ESFRI process is fed by a wide range of requirements. Synthesis links all related project outcomes, scientific communities, the site and platform network as well as the ESFRI process.

1.1 Whole System Approach (Work Package 8)

In addition to more traditional disciplines in long-term ecosystem research and monitoring (covering the geo-, hydro-, bio- and atmosphere), eLTER is currently the only environmental RI that also addresses the social and economic sphere at local-to-continental scales. To reflect the broad thematic coverage, the four Research Challenges RC 1 Biodiversity Loss, RC 2 Biogeochemical Controls of Ecosystem Functions, RC 3 Climate-Water-Food Nexus, RC 4 Socio-Ecological Systems are incorporated into eLTER PLUS, using available data and services to formulate and execute case studies in ecosystems and socio-ecological research. Acknowledging the systemic interlinkages and feedbacks between the natural and social domains of the Earth system across spatial and temporal scales (Haberl et al., 2016; Collins et al., 2011), another feature of eLTER RI is to address these scientific and societal challenges with the Whole-System Approach for In-situ Research on Life Supporting Systems in the Anthropocene (WAILS) (Figure 2).

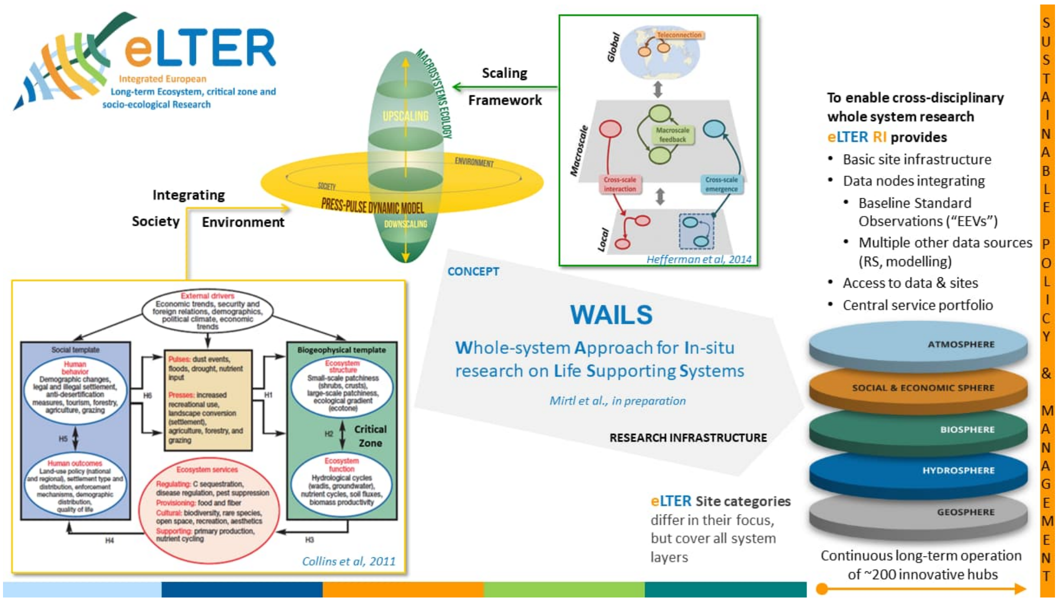

Figure 2: Schematic representation of the WAILS approach and its interlinkages across disciplinary boundaries and spatial scales. (Source: Mirtl et al., 2021)

"The eLTER Whole System Approach encompasses the Earth system and related domains/disciplines from geosphere to the hydrosphere, biosphere and socio-econosphere to atmosphere. [...] eLTER RI implements the Whole System Approach across its hierarchy of in-situ facilities (sites and platforms). The disciplinary methods and research challenges are addressed by the sites in a comprehensive manner (in highly instrumented sites), or more simple (less instrumented sites). eLTSER platforms have largest spatial extent and focus on investigating human society-environment interactions in the long term." (eLTER PLUS Proposal, 2019, p 123)

WAILS is directly addressed by WP 8 of the eLTER PLUS project: "WP8 will explore how long-term biodiversity, biogeochemistry, hydrology and socio-ecology data of the eLTER network can provide the necessary holistic understanding of the ecosystem response to environmental (e.g. land use and climate change) and societal pressures. WP 8 focuses on the capacity of the design, data quality and data services of eLTER Sites. This will be delivered through four Tasks (Case Studies, CS), and a synthesis Task. WP 8 will focus on the site and catchment scale. We will work together with WP 7 to obtain the necessary data required to deliver on the objectives of Tasks 8.1-8.4 via TA, VA and RA [trans-national, virtual and remote access]; and with WP 10 to pilot key data workflows for the specific topics (trialed within data labs from WP 11). [...] The CSs will focus on a common theme 'extreme events', and in addition will investigate other stressors important to individual science areas. Task 8.5 will provide a synthesis of CS 1-4. Resulting data will serve as validation of the pan European scale synthesis in WP9." (eLTER PLUS Proposal, 2019, p 165)

1.2 Aim of the document

The primary objective of this deliverable is to summarize contributions of Task 8.4 to connected working groups in eLTER PLUS and derive conclusions from the CS to inform development of eLTER RI, in particular the SO framework, development of data products and services, eLTSER platform design and management, as well as WAILS. According to the project framework and task definition as well as previous assessments of socio-ecological research in eLTER RI, Deliverable 8.4 is structured as follows:

In Chapter 2, we will introduce RC 4 Socio-Ecological Systems and define our scientific approach to the CS in Task 8.4 (2.1) as well as the linkages with other tasks and work packages within eLTER PLUS (2.1.1).

In Chapter 3 we describe our methodological approach, materials and methods, in particular our top-down (3.1) and bottom-up data strategies (3.2).

Chapter 4 presents the results. We outline socio-ecological research frontiers, data requirements and availability gaps (4.1), focusing on two central research themes, two distinct long-term approaches, as well as transdisciplinarity and qualitative data. We then proceed to present preliminary results from the CS (4.2) in the three study regions. This sub-chapter is just a first and exemplary outlook in the empricial results of the science case. Data collection and analysis is still in process and will be submitted as peer-reviewed paper in the course of 2023.

2 Socio-Ecological Systems (Research Challenge 4)

A holistic understanding of complex socio-ecological systems (SES) across spatial and temporal scales is found to be a pre-requisite to address current and future sustainability challenges in an adequate manner, achieved by inter- and cross-disciplinary methods covering the natural and social sciences, as well as by transdisciplinary approaches driving the integration of stakeholders (Singh et al., 2013; Haberl et al., 2006).

2.1 Analysis of stakeholder-defined local and regional environmental challenges (Task 8.4)

Within this framing of SES, Task 8.4 is concerned with the socio-ecological analyses of stakeholder-defined local and regional environmental challenges. The CS conducted in three eLTSER platforms (Eisenwurzen, Doñana, Braila Islands) is informed by the socio-ecological research framework to characterize interactions between social and ecosystem variables (Haberl et al., 2016, 2006) and the Press-Pulse-Dynamics (PPD) framework (see in Figure 2) (Collins et al., 2011), emphasizing presses and pulses on the ecosystem as well as resultant changes in the provision of ecosystem services and human behavior.

In addition to generally defined local and regional environmental challenges and conflicts, the aim of the CS is to advance understanding of the impact of climate change and extreme weather events on land use and land-use change on a local-to-regional level. To this end, we strive to define the study regions' most pressing climate change impacts related to land use and management as well as different land users' perceptions, vulnerabilities and implemented or potential adaptation measures and strategies. We characterize these dynamics in terms of interactions between social and ecosystem variables, emphasizing social and natural "presses and pulses" on the ecosystem, ecosystem response, and resultant changes in the provision of ecosystem services. Furthermore, we identify the socio-economic and biogeochemical variables required for understanding these socio-ecological relationships and feedbacks. Analysis will be conducted through a combination of top-down and bottom-up approaches, including qualitative and quantitative data and methods as well as the integration of local stakeholders (such as resource managers, farmers, tourism operators, and environmental organizations) into the research process (see Chapter 3). We therefore include national and supra-national as well as regional and platform-based data, such as statistics and remote-sensing data, as well as in-situ ecological measurements, and historical and qualitative data from transdisciplinary processes, respectively.

All the empirical quantitative and qualitative work done within our case study in 8.4 serves as a basis to extend the land-use decision-making model SECLAND (Egger et al. 2022, 2023; Mayer et al. 2022; Dullinger et al. 2020) in a follow-up project LUCCA (a three-year (2023-2025) project funded by the Austrian Academy of Science (OEAW)). SECLAND is an agent-based model developed in the Institute of Social Ecology, Vienna that allows the simulation of land use decision making processes of land users under different socio-economic and climatic scenario conditions.

Many agent-based models distinguish their farm-agents based on the type of agricultural production (Beckers et al., 2018; Brandle et al., 2015; Zimmermann et al., 2015) or occupancy type and economic orientation (Acosta et al., 2014; Holtz and Nebel, 2014; Troost and Berger, 2015; Millington et al., 2008; Valbuena et al., 2010), but there is rarely any consideration of a farmer's value system (Huber et al., 2018; Malawska et al., 2014). Malawska et al. (2014) integrated three farming styles (yield optimizer, profit maximiser and environmentally-oriented farmer) into the pre-existing FOM (farm optimization model) to compare the diverging outcomes with the original, economic optimization results. With SECLAND, we have taken up and deepened this approach by comprehensively mapping farming styles and integrating them not as a supplement to the model, but as essential part of it. In combination with the wellbeing criteria, the farming styles have a direct influence on decision-making and thus enable the integration of heterogenic factors beyond pure economic rationality. This improves the explanation of diverse farmers' decision-making in reaction to changes in the socio-economic framework conditions (Schmitzberger et al., 2005; Daloglu et al., 2014). We based the agent typology on farm types and, to include farmers' value system, farming styles. SECLAND omits the distinction between full-time and part-time farming, as the model design allows its agents to gradually subsidize the agricultural income with off-farm work within its time limits.

The model produces spatially explicit land use maps and results in terms of socioeconomic performance indicators (income, working time, etc.) of land users. The current version of SECLAND will be closely linked to the WAILS approach by creating a module that can be combined with ecosystem models used in the tasks 8.1 – 8.3 within WP 8. The land-use decision-making model will be adaptable to different study regions (e.g. LTSER Donana, Spain) and extended by a better integrating of extreme weather events and climate change risk. Additionally, the model will be extended to simulate additional actor groups (e.g. foresters) and will be used in order to introduce communication between actors and subsequently foster social learning.

2.1.1 Relevance and linkages within eLTER-PLUS

<u>WP 3 Standard Observations framework</u>

We have contributed to the discussions on social-ecological standard observations (SOs) in WP 3 based on the findings from our case study in 8.4 by (1) identifying key third-party quantitative data sources

(EU and national statistics) and (2) developing a protocol for standard observations on governance and stakeholders (in close cooperation with Task 9.4). Based on our stakeholder analysis questionnaires and the Social Network Analysis in 8.4 (see Chapter 3), we will identify the main indicators that should be collected regularly as part of the social-ecological standard observations.

WP 7

Trans-national access (TA) was planned and initially funded, but the pandemic made traveling and personal interactions across multiple borders unfeasible and risky. Uncertainty about future developments led to various rounds of short- to medium-term rescheduling of the planned platform visits, until we decided (in accordance with eLTSER platform managers and WP 7) to make a switch in strategy and to perform the CS via remote access (RA). This was a new approach for us as well as the eLTSER managers, because on the one hand we had to adjust to conduct qualitative interviews over the internet, and on the other hand this process also demanded a more constant and pro-active involvement from local staff. This mode of conduct nevertheless proofed to work quite well, so we decided to stick with this strategy and shift TA into the follow-up project LUCCA (see above) starting in 2023.

WP 8 Whole Systems Approach

The decision to focus our case study in 8.4. on land use was made in consideration of the fact that the other tasks (8.1-8.3) in WP 8 use ecosystem models, all of which use land use and land use change as a key input variable for initializing their models. This is the reason why we decided to use our case study as a prerequisite for adapting our land-use decision model SECLAND (see above), in order to improve this simulation model in follow-up projects so that it becomes connectable to the different ecosystem models in WP 8 to fulfill the WAILS approach on a modeling basis. Consequently, the development of our case study was done in close collaboration not only within the Research Challenge Social Ecology, but also within WP 8.

WP 9 Upscaling policy implications

Throughout, we worked closely with Task 9.4, which analyzes socio-environmental challenges at the continental scale. Since 9.4 will have a focus on the Donana LTSER platform, we have been conducting our empirical work on stakeholder and social network analysis specifically for this platform cooperatively with 9.4 (e.g. conducting interviews together, etc.). On a conceptual level, the goal is to link our case study on land use decision making at the local scale with the work in 9.4 on governance structures and institutions at the national and EU levels and how these affect land use at the local and regional levels. Accordingly, this collaboration will continue until the completion of 9.4 (month 48).

WP 10 Work flows, data products, and services

The issue of data requirements for the study of socio-ecological systems is a relatively new one, with little guidance on what can be considered "essential" variables for understanding the dynamics of coupled social and ecological systems. Aside from being a new endeavor, essential data for understanding socio-ecological systems include both quantitative and qualitative variables. Working closely with WP10, we provided information for the workflows to collect (1) qualitative data based on the stakeholder and social network analysis conducted in this science case in 8.4 and (2) quantitative data to initialize the SECLAND land-use decision model (future work in follow-on projects within eLTER).

3 Materials and methods

The main objectives of Task 8.4 were on the one hand 'scientific' in terms of implementing a socio-ecological CS to test the existing eLTER RI in designated LTSER platforms, and on the other hand 'operational' in terms of deriving inputs from this case study for RI development. These two objectives confronted us with a *dichotomous dilemma*, namely how to derive generally valid insights for RI development from one specific, thematically and methodologically delimited case study, which could never be *all-encompassing*. A similar dichotomy can also be found when referring to the development of the SO framework, where the definition of a certain set of socio-ecological variables will never cover the breadth of socio-ecological research, and as such definition of this dataset would always fall short of actual research requirements being present in individual projects and studies.

To nevertheless being able to address both objectives consistently, we adopted a research strategy that is conceptually as well as practically characterized by the systematic integration of top-down and bottom-up approaches (Figure 3). The top-down approach, on the one hand, addresses the identification and normative definition of socio-ecological research themes, their data and service requirements as well as potential availability gaps and access restrictions. The bottom-up approach, on the other hand, consists of performing a functional test of the running RI's products and services at the eLTSER platform-level. Combining the selected approaches then allowed us to generate a range of diverse scientific and operational insights for RI development. The following sections describe the methods we applied for the two approaches.

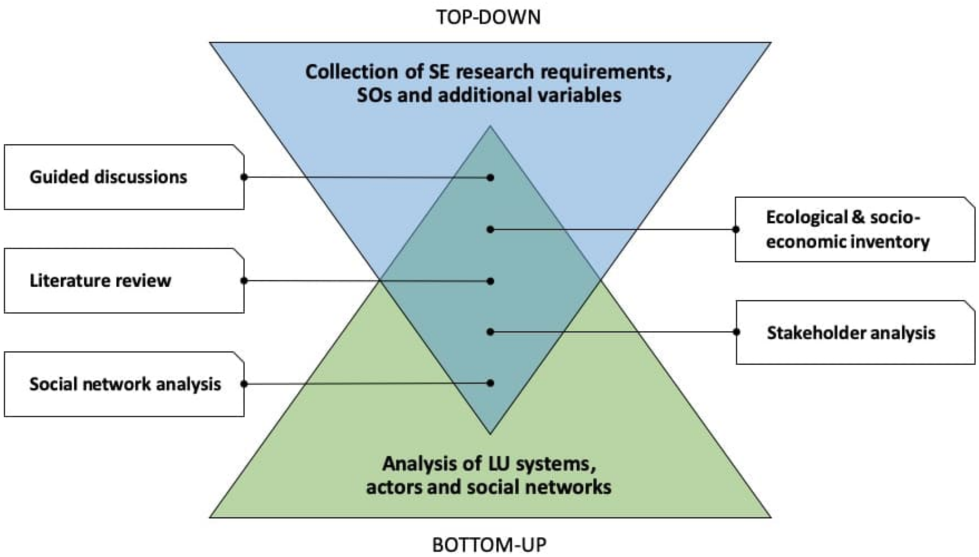

Figure 3: Schematic of research strategy showing the integration of top-down and bottom-up approaches as well as individual methods used for implementation of local case studies and RI development.

3.1 Top-down approaches

3.1.1 Identification of research requirements

To review and complement the current understanding of socio-ecological research within the eLTER community (Orenstein et al., 2019) and to systematize and formalize prevailing research themes and their requirements, we conducted a series of guided discussions with leading experts from the Institute of Social Ecology at BOKU University, Vienna, on the topics of colonization of natural systems (Assoc. Prof. Karlheinz Erb, July 2020), social metabolism (Prof. Helmut Haberl, Dr. Dominik Wiedenhofer, August 2020), environmental history (Assoc. Prof. Simone Gingrich, Assoc. Prof. Martin Schmid, Sept 2020) and transdisciplinarity (Dr. Willi Haas, Dr. Barbara Smetschka, Sept 2020Error! Reference source not found.). The aim of these discussions was to identify, from a practical viewpoint within the respective field, current research frontiers, data requirements and availability gaps as well as implications for product and service development in eLTER and its network of sites and platforms.

The outcomes from these discussions were then systematized and complemented with inputs from relevant literature, to be fed into the development of the SO framework, RI products and services as well as LTSER platform design and management (Chapter 4.1).

3.1.2 Collection of quantitative data

For implementation of the ecological and socio-economic inventories we harvested a set of previously collected SOs (according to the eLTER PLUS Deliverable D3.1) from a data repository realized by WP 4 in co-operation with respective LTSER platform staff, as well as different additional socio-economic and ecosystem variables identified as important in respective regions as well as for the synthesis in Task 8.5 and the WAILS approach. Examples of these variables are Land cover (geo-spatial raster data from CORINE Land cover, CLC2018), Crop production (tabular statistical data from national statistical offices), or Population data (tabular statistical data from national statistical offices).

We then applied the eLTER cookie-cutting tool, which allows for masking gridded data as well as for aggregating non-gridded data to eLTER site and platform boundaries via a web-interface (https://datalab.datalabs.ceh.ac.uk), where necessary, to down-scale datasets to the three LTSER platform boundaries, as provided by DEIMS-SDR. Applying the cookie-cutting tool to distinct datasets (pertaining to data type and resolution, e.g. raster data from remote sensing versus tabular data from statistical sources) allowed us to formulate feedback for its applicability in different use cases. Down-scaled data were then used to describe socio-ecological aspects of each land-use system from a quantitative perspective and to create the ecological and socio-economic inventories.

3.2 Bottom-up approach

Besides the more general top-down description of the land-use systems under study using the above-mentioned dataset collected from official and public sources, we focused on the bottom-up identification and description of interrelations between local and regional (i) environmental challenges, (ii) land-use actors, and (ii) climate change impacts and adaptation.

The bottom-up approach consists of a four-step process involving application of qualitative and quantitative methods (Figure 4). The first step consisted of launching a literature and data call to LTSER platform managers to collect existing relevant literature and data for each study region. This call returned a wealth of peer-reviewed literature, as well as reports and other documents. The second step served to identify, together with the LTSER platform managers, relevant experts to potentially conduct interviews with. The third step was then to conduct a series of qualitative expert interviews to perform a land-use systems and stakeholder analysis. The fourth and final step was to conduct a social network analysis of each land-use system with a focus on the information flows between stakeholder groups in the context of land use and climate change.

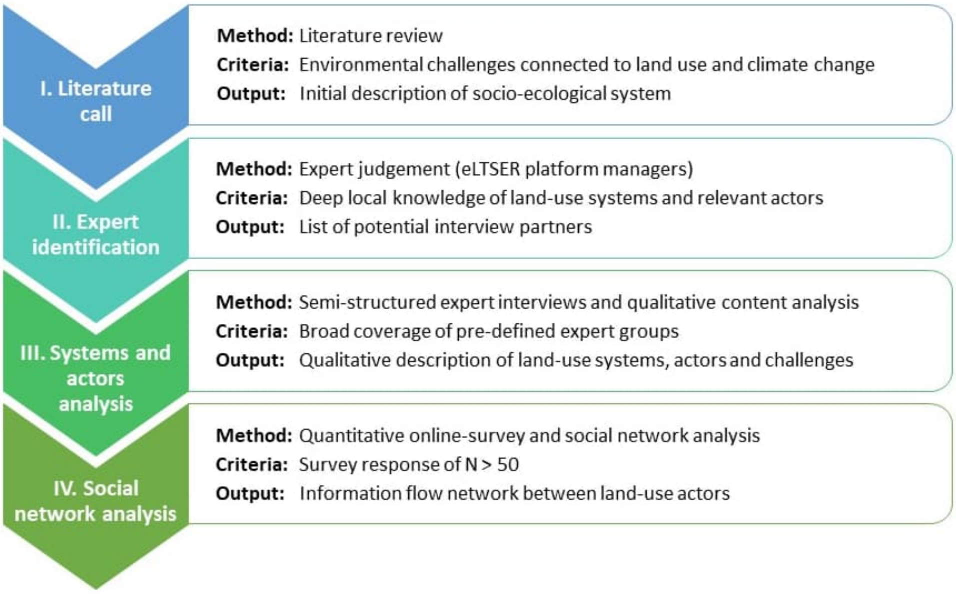

Figure 4: Schematic representation of the four-step bottom-up approach

I. Literature and data call

A literature and data call was submitted to LTSER platforms in April 2021 to gather pre-existing materials relevant to our thematic scope. The call asked for literature and data from qualitative and quantitative sources covering land use and land-use change, environmental and sustainability issues, ecosystem services, land-use actors and decision-making as well as climate change and extreme weather events. Answering this call, we received a pool of scientific literature from LTSER platforms spanning this broad thematic scope and beyond. The literature was then screened to further develop the ecological and socio-economic inventories as well as to assess the level of research which has already been conducted in the respective platforms.

II. Expert identification

The aim was to identify, together with the LTSER platform managers, potential interview partners from a diverse group of local land-use experts and representatives covering a region's main land-use types (i.e. agriculture, forestry, tourism, conservation, infrastructure) as well as its structures and configurations. Potential expert groups were pre-defined according to work done in previous studies (LUBIO; CHESS) led by the task leader and included the following: (a) land users (e.g. land owners and managers representatives), (b) extension and consulting services (e.g. chamber of agriculture, private consultants), (c) science and conservation (e.g. local researchers, national park personnel), (d) regional development initiatives (e.g. LEADER, Interreg), (e) politics and administration (e.g. mayors, authorities personnel), (f) environmental protection advocacy groups, (g) tourism representatives, and (h) agri-business representatives.

III. Land-use systems and actor analysis

We conducted a series of semi-structured qualitative expert interviews with those individuals identified in the previous step. Interviews were conducted between November 2021 and October 2022. The minimal sample size for the qualitative thematic analysis was set to N=12 per study region to reach thematic saturation (Guest et al., 2006; Hennink & Kaiser, 2022; Saunders et al., 2018). Criteria were that expert interview partners should have deep knowledge about the local land systems and their sustainability issues, be well connected and experienced in dealing with local stakeholders and cover the predominant land-use types in each study region.

For Eisenwurzen, this was reflected in a focus on grassland agriculture, forestry and conservation, and less focus on cropland agriculture and tourism. We interviewed two researchers of whom one is also a local dairy farmer, two public consultants from the chamber of agriculture (who themselves are also mixed cattle, dairy and forest farmers), one private local forestry consultant, one conservation manager from the Austrian Federal Forests, one forestry manager of a large local land owner, one official from the regional nature protection authority, two national park employees, one regional development managers who is also working in one of the local nature reserves, and one representative from a local tourism association (N=12). For Doñana, a large focus was set on hydrological aspects, water management and conservation, and those agricultural land uses with the strongest connection to these topics. We interviewed three researchers (two conservation scientists and one hydrologist) of whom one is also working in the national park, one official from a local water authority, one tourism representative who is also a researcher and consultant, three farmer representatives (from each a local wine, cattle and rice cooperative), one red berries farmer, one representative from a local irrigation community, one private agricultural consultant, one environmental activist from a local NGO, and one technical official for agriculture and conservation from the local public sustainability council (N=13). For Braila Islands, momentarily there still exists a slight bias towards conservation, but the interview cycle has not yet been completed. We interviewed three researchers working in the field of conservation and social ecology, one researcher in the field of agricultural sciences, one local farmer, one mayor of a local municipality and one environmental activist from a local NGO (N=7).

The interview guideline was set up to first enquire about the interviewee's personal background and connection to the region, then move on to the issue of land-use change and connected sustainability challenges, then solicit information on the most relevant land-use actors with a focus on power relations and conflicts, and finally to ask about the impacts of climate change and extreme weather events, actors' perceptions and vulnerabilities as well as actual and potential adaptation measures. Interviews took place remotely via a video-conference software and were facilitated, in the case of Braila Islands and Doñana, by the platform managers (in a few cases even in the absence of the principal researchers). Interviews took between 60-90 minutes each and were transcribed and translated based on audio-recordings.

We then conducted a thematic content analysis (Braun et al., 2019; Kiger & Varpio, 2020) by coding and analyzing the interview transcripts with Atlas.ti software to identify and extract information on land-use change and the relevant actors in the context of environmental challenges, climate change and adaptation.

IV. Social network analysis

The primary objective of this step was to quantify and analyze the information flows between different actors of each land-use system. We used an online-survey to solicit information from each respondent on demographic variables, socio-economic and farm-structural variables if the respondent owned or managed a farm, as well as communication variables in the context of land use and climate change. As the systems under study were unbounded networks, definition of a minimum sample size was difficult to pin down, and was finally decided between relative representativeness and practicability. Previous expert interview partners then served as entry points to distribute the survey to potential stakeholders using a snowball approach, aiming at a minimum sample size of 50 respondents per region. The survey covered three main thematic categories: (i) socio-demographic variables, (ii) farm structural and management variables, and (iii) network and communication variables. Socio-demographics included location, sex, age, education, and assignment to pre-defined actor groups. Farm structural and management variables included crop/livestock/forest types, farm size, climate change adaptation measures, full- or part-time farming, number of farm workers, organic farming, and fertilizer/pesticide costs. Network and communication variables included assignment of the most important communication partner to (the same) pre-defined actor groups, personal relation, frequency of communication about a series of land-use related topics, directions of the information flow, and influence of the communication on land-use decision-making. Respondents had to provide at least one, and potentially up to three, communication partners.

Using these data, we created node and edge tables and used the open-source software Gephi to create corresponding network. We then systematized the data by (i) differentiating sub-networks for the agriculture and forestry sectors, (ii) creating different clusters based on farm structural variables and communication themes, (iii) aggregating individual respondents into actor groups treating them as a single node each, and (iv) merging duplicate edges between those groups by summing up frequency and influence values. Steps (i) and (ii) allowed us to account for the heterogeneity of the land-use sector and its actors and to compare different groups in terms of their individual communication characteristics. As this analysis tackled relatively large and unbounded networks without collection of a unique personal identifier for each individual actor/node (such as a combination of name and birth date), steps (iii) and (iv) enabled us to calculate the degree centrality for each actor group/node to identify the most important information hubs and communication leaders (e.g. node size=number of in- and outgoing communications; node colour= number of intra-group communications, edge weight and colour=frequency and influence of communications).

4 Results

This section will loosely follow the structure of our strategic approach. In a first step, we will provide a summary of the collection of socio-ecological research requirements. In a second step, we will present results of the CS in the form of *socio-ecological land system profiles* for each of the three LTSER platforms, consisting of a quantitative and qualitative description of the land systems under study.

Due to recurring delays and changes in research design and implementation caused by the Covid-19 pandemic as well as by differences in the resource availabilities of platform staff, results are preliminary and progress on the three platform profiles is at different stages. For obvious reasons pertaining to our residence in Austria, research done in LTSER Eisenwurzen could progress faster than in the other two platforms. This was driven by the fact that we had extensive pre-existing knowledge about the region, data access points and, most importantly, stakeholder contacts. Language also played a minor role. Research in Doñana could also progress substantially, foremost owed to the fact that we were primarily working together with a LTSER platform employee who has his own stakes in eLTER PLUS (i.e. Task 9.4 Lead Pablo F. Méndez) that are closely connected to our work in Task 8.4. Research in Braila Islands could progress the least, mostly owed to the fact that LTSER platform staff seemed overwhelmed in terms of work load and time demands resulting from our switch to RA for qualitative data collection.

4.1 Socio-ecological research requirements

To start off this section, we very briefly summarize key research that was done in previous eLTER projects to assess the overall integration and progress of socio-ecological research in LTSER platforms. These assessments emphasize LTSER platforms' general representativeness of European diversity, but reveal only tentative progression in integrating social sciences and transdisciplinary approaches. Platforms and sites are generally balanced biogeographically, well-placed for ecosystem services assessments and representative of socio-ecological diversity, but are slightly biased against natural and semi-natural as well as low economic density areas (Angelstam et al., 2019; Dick et al., 2011; Mollenhauer et al., 2018). Integration of social sciences and socio-economic variables is still slow, not prioritized or incentivized by platforms, lacking harmonization, and largely depending on local context and individual project leads (Angelstam et al., 2019; Dick et al., 2018; Holzer et al., 2018, 2019; Mollenhauer et al., 2018). Furthermore, stakeholder integration is not strategically planned and institutionalized, very heterogeneous, often happening due to funding requirements and usually not playing a role in setting the research agenda (Holzer et al., 2018, 2019). Standardization and harmonization of methods and data as well as development of sites and co-located site networks will be necessary for high complexity research and policy relevance, and raises the issue of compatibility with and robustness of long-term time series (Dick et al., 2011; Holzer et al., 2018; Musche et al., 2019).

These assessments generally point to the important fact that eLTER is not yet very visible and attractive for social scientists and that more effort needs to be put on this matter. This was also one of the central statements in a key note by Prof. Helmut Haberl at a SES group meeting (virtual) in the course of the eLTER PLUS project. Development of stakeholder integration using a harmonized framework and requirements for LTSER platforms will play an important part in this endeavour. At the same time, another key aspect lies in the expansion of the understanding and conception of socio-ecological research within eLTER. While the focus on transdisciplinarity is important and warranted, other socio-ecological research approaches, in particular those working with quantitative and mixed methods and data, need to be strengthened, too. While there is a focus on modelling, another gap that has not yet been addressed systematically pertains to environmental history, which should have an active role particularly in a long-term research environment.

4.1.1 Research themes

To systematically address the objectives of Task 8.4, we chose to introduce five sub tasks aligned with the central themes and methods of socio-ecological research (Figure 5) to inform our feedback on the development of the eLTER SOs, eLTSER platform design and management as well as specification of eLTER RI tools and services. The two core concepts – colonization of natural systems and social metabolism – address research on land use and resource use and apply and integrate inter- and transdisciplinary methodology as well as qualitative and quantitative data from the natural sphere (i.e. biodiversity, biogeochemistry and hydrology, addressed by Tasks 8.1–8.3 and 9.1–9.4) and the social sphere (i.e. socio-economy, communication and human agency as well as governance and policy, addressed by Tasks 8.4 and 9.4).

To ensure a long-term and co-evolutionary perspective on society-nature interrelations and sustainable development, environmental history critically analyzes historical sources and data covering the use of land and other natural resources in the past. Integrated socio-ecological modelling aims to reconstruct and project complex society-nature interactions, such as interrelations between the decision-making of individual actors, socio-economic processes and political framework conditions as well as biophysical and ecological developments. Participatory processes help to shape the research agenda, co-produce data and knowledge and facilitate implementation and impact. This requires establishment, maintenance and development of a stable network of relevant stakeholders. A unique aspect of socio-ecological research contrasting the natural-science based science community is the collection and application of qualitative data, which in turn also need to be managed actively (including various aspects covering data deposition and archiving as well as data sharing and secondary use).

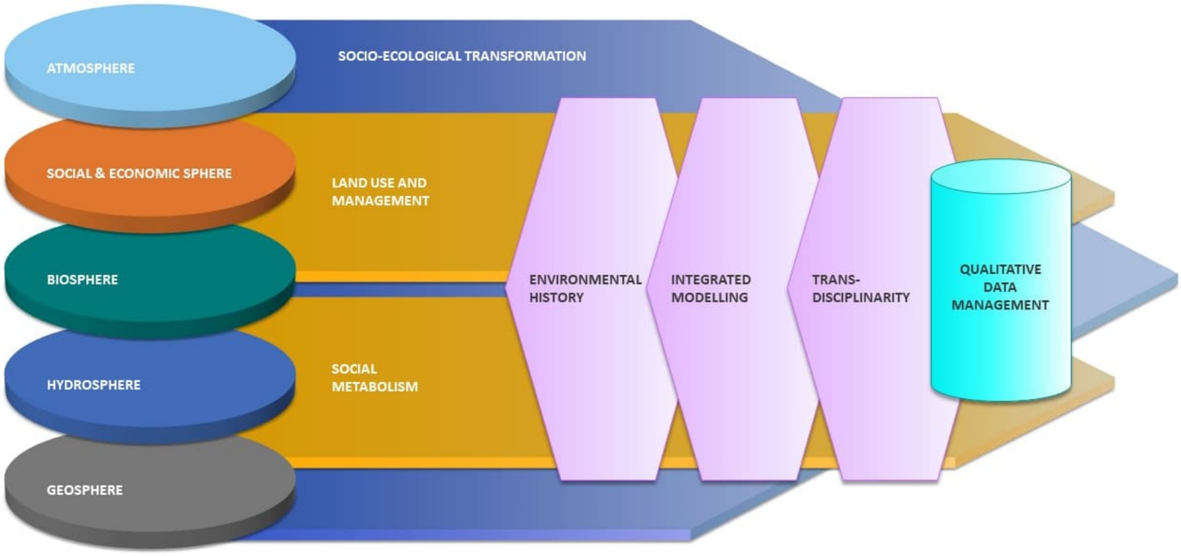

Figure 5: Socio-ecological research themes (blue and golden arrows) integrate between different eLTER system layers and corresponding research challenges (biogeochemistry, climate-water-food, biodiversity), methodological approaches (pink hexagons) and qualitative data (turquoise).

Colonization of natural systems

Land use is a central topic addressed in sustainability science, a nexus for combination of social and natural sciences, and also a prominent theme addresses by the eLTER research community. Ecosystem research is often connected to land use, as agricultural and forestry practices (as well as other forms like infrastructure development, energy production, mineral extraction or waste management) affect ecosystem structure and functions, and thus the provisioning, regulating and supporting ecosystem services such as biodiversity, climate and water regulation, provision of food and materials or recreational and spiritual services. Land system science in a socio-ecological context can be summarized as 'the normative search for effective responses to major challenges in the land system across spatial and temporal scales, and analysis of the systemic feedbacks between the social and ecological spheres of influence'. A network of eLTSER platforms is thereby able to deliver a suitable environment for comparative and place-based case studies to analyze interrelations at the local-to-continental level between land-use decision-making, institutional and political frameworks, social and economic organization, development of ecosystem structure, functions and services, effects on biophysical stocks and flows as well as impacts of and on global climate change and extreme weather events.

Besides the different land-use types, management intensity is a central factor when accounting for changes within the PPD framework, affecting the eco- as well as the social systems (Erb et al., 2016). Most of the structural changes in the land system go through the 'needle hole' of human decision-making, which often manifests on a relatively small scale and day-to-day basis by individual land users. Analysis of these interrelations is complex (Figure 6): not only intended effects have to be considered, such as increasing societal inputs into ecosystems to generate higher outputs, but also unintended side effects occur within ecosystems (such as soil degradation or biodiversity loss) as well as social systems (such as production-consumption interlinkages leading to competition between food, feed, fiber and biofuel, or global teleconnections resulting in the externalization of risks and costs). Feedbacks within the social system may produce trade-offs, potentially transforming solutions into novel problems and future threats (such as the interrelation between the intensified use of forest biomass to substitute fossil energy and the development of forest carbon stocks for climate change mitigation). Combination of qualitative and quantitative data and inter- and transdisciplinary methods allows for identification of drivers, analysis of press and pulse dynamics and reconstruction of mechanisms and feedbacks altering the quantity and quality of ecosystem services via changes in the structure, functioning and behavior within the social and natural spheres of influence.

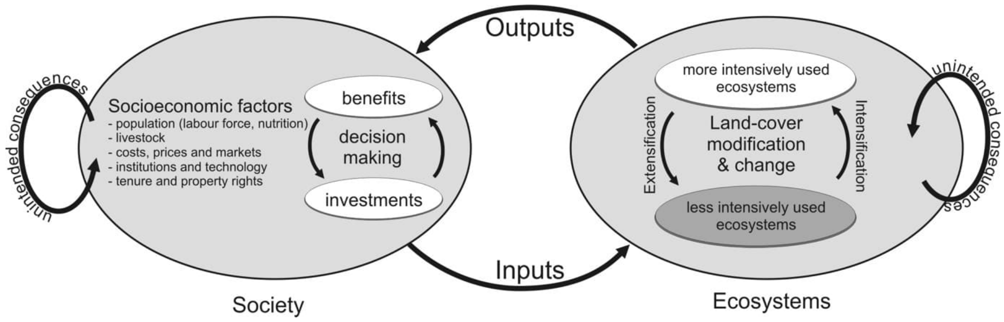

Figure 6: A socioecological metabolism perspective on land-use change and intensity (Source: Erb et al., 2016)

Current research frontiers include but are not limited to three main themes: (i) drivers and effects of land management and land use change, (ii) 'options for action' and their potentials, systemic feedbacks, trade-offs and synergies, and (iii) temporal and spatial scale effects, non-linearities and nested structures. The first theme includes enquiry into the drivers of land management and land-use change in its particular form and the influencing factors standing behind those drivers. This includes identification, mapping and analysis of land-use actors, management practices and the related social and ecological effects. In this regard, it is also pivotal to understand how land use and management interact with the geo-, hydro-, bio- and atmospheres, as well as with the socio-economic, -political and -cultural spheres. The second theme revolves around potential option spaces of land use and management, in particular addressing the critical issues of climate change impacts, adaptation and mitigation; biodiversity loss, erosion control, nutrient cycling and eutrophication; as well as nutrition and food security. Systemic feedbacks, trade-offs and synergies concerning different land use and management options need to be quantified, again considering interacting repercussions between the natural and social systems. The third theme is related to research addressing different spatial and temporal scales, such as up- and downscaling systemic effects that emerge from actions and responses on different local-to-global levels and within nested structures, reaching from the past into the future. This strand of enquiry also includes spatial and temporal thresholds of synergistic or antagonistic side-effects, identification of trigger points and analyses of non-linear developments and emergent phenomena; enquiry into when, where, how and why pressures and impacts have already turned or may turn in the future into drivers; as well as analyses of the effects of land-use legacies on current and future social and biophysical dynamics.

To address this broad range of research topics, detailed comparative data is necessary at its highest resolution, as well as in aggregated form at the continental-to-global scale. These data pertain to (i) the land-use actors (the 'who') such as agricultural and forestry holdings on the micro- and meso-sphere; (ii) production data (the 'what' and 'where') such as yields and harvests for each land use type and management intensity (in particular also including high resolution livestock and forestry data), as well as data on production losses due to biotic and abiotic stressors; (iii) data on applied management intensities and strategies (the 'how'), including fertilizer, herbicide and pesticide application, technical and mechanical measures as well as livestock feed management; (iv) data on driving forces and influencing factors (the 'why'), covering decision-making processes, governance and ownership structures, subsidy and regulation regimes, detailed trade data across the global value chains, as well as environmental and biophysical drivers. Data gaps pertain to most socio-economic data sets on small spatial scales (national-to-NUTS 3 (i.e. small regions for specific diagnoses, following the Eurostat

Nomenclature of terrestrial units for statistics) and smaller), such as consumption data or local-to-regional trade data (which is generally heavily restricted).

Social Metabolism

Even if in our Science Case in 8.4 Social metabolism as such is not in the focus it is important to keep this research strength in mind as social metabolism and its understanding is a pre-requisite in order to understand the drivers of land use change across spatial and temporal scales. The reproduction of human populations as well as economic production and consumption processes require material and energy flows that have, in their entirety, been denoted as “socioeconomic metabolism” (Ayres and Simonis 1994, Fischer-Kowalski 1998). In an LTSER context, the metabolism concept can be expanded by explicitly linking socioeconomic flows to the material and energy flows within regional ecosystems. The result is an integrative analysis of a region’s full socioecological metabolism, the grand total of socioeconomic and ecological biophysical flows. This in turn facilitates integrated analysis of natural and cultural drivers of change, especially land use change. The flows and stocks of greatest interest in the LTSER context include those of air, water, soil, living biomass, dead organic matter, nutrients, and toxic materials. Global and local biogeochemical cycles involving carbon, oxygen, nitrogen, phosphorous, sulfur, etc. can be, and have been, significantly affected by human activities. In the context of LTSER in eLTER and related to the requirements of the eLTER RI the following research questions might be of specific interests for future LTSER research in eLTER:

- Where and how is production or consumption a driver for which kind of land use system in a specific area?
- What are the tele-connections between production and consumption influencing local to regional land use systems?
- Which biophysical prerequisites for land use exist in a specific region (e.g. for which kinds of jobs, industries etc.)?
- How and where does resource use from building, maintaining and using societal stocks drive land use and land management?
- How do long-term lock-ins of resource use patterns (land, energy, etc.) influence land use decisions and policy from a local to a continental and global scale?

4.1.2 Integrating long-term research from the past to the future

Here, we focus on methodological approaches which are particularly relevant for eLTER RI, as they allow for research connected to social metabolism and colonization of nature covering long-term perspectives and processes.

Environmental History

Environmental history utilizes a broad range of historical and archival data sources to analyze the co-evolution of the natural and social systems in a given region. Very often these data are not yet (fully) digitized and archives usually require in-person visits to identify and collect relevant sources. Due to the sheer amount of historical material and the large body of critical issues regarding digitization of such data, it will not prove in any way feasible to start digitization efforts within eLTER RI. Digitization and provision of historical material should therefore not be the task of LTSER platforms but of the respective archives themselves. Nevertheless, many archives will not have the agenda or resources to implement such digitization efforts. eLTSER platforms can thus offer specific “connecting services” that facilitate and support research in the field of environmental history. The following four services were identified.

a. *Interface personnel to mediate between environmental history stakeholders and socio-ecological researchers*

Interdisciplinary scientific personnel should be available in the platforms to facilitate the work of visiting environmental historians. Ideally, these highly trained staff (also known as the "guardians of the cultural heritage") have in-depth knowledge of regional history and its relevant local sources, as well as a broad understanding of ecological and socio-ecological research approaches, their methods and data demands. Besides possessing the local historical and archival knowledge, respective platform staff should be able to discern specific scientific questioning that can be applied to a given archival-historical material as well as the specific stocks/data that are potentially suitable to answer given research questions. Furthermore, personnel should have direct contact with regional institutions and related processes, such as private or public research institutes, museums, public associations, private holdings and civil society events. Engaging with environmental history stakeholders could be facilitated by implementing this topical orientation in a platform's organizational structure, e.g. by hosting relevant events or activities.

b. *Database of regional historical-archival institutions*

Visiting socio-ecological researchers can profit immensely from an easy entry point into the realm of local historical knowledge. eLTSER platforms should therefore maintain a database with all relevant (public and private) historical research institutions, museums and archives that exist in a region. This database should include meta-information on the preserved cultural heritage, inventory and holdings. Metadata should be in accordance with the state of the art of archival and librarian sciences. The database should also include contact to specific staff who is located in the respective institution. This database does not only facilitate actual socio-ecological research, but can also be an important tool for researchers to scope potential data availability during formulation and planning of research proposals. This database can therefore be a tool for raising the addressability and attractiveness of a given eLTSER platform to researchers form the social sciences and humanities scoping eLTER RI for potential case study regions.

c. *Historical profile of the region*

A regional historical profile (ideally peer-reviewed) connected to social metabolism and land use, including the central political and socio-economic history of a region, its evolution of administrative structures, ownership and tenure rights as well as governance and power relations, should be available in eLTSER platforms. Integration of such a body of historical understanding (whereby the time frame can vary considerably depending on the beginning of human settlement in the respective regions) into an eLTSER platform's knowledge base would imply added value to potentially available historical material itself and create an additional asset to attract international and inter-disciplinary researchers. Historical profiles can, in certain cases, be ambiguous and even prove problematic, as regional historical knowledge may be cultivated in a biased or identificatory (sometimes nationalistic) manner. In this context, the creation of a largely un-biased historical profile could also be seen as a chance for a "transnational" and "ecological" framing of regional and local history and contribute to the entangling of historical sources for conflict.

d. *List of past environmental history projects*

In addition, platforms should maintain an up-to-date record of finalized research projects identified as environmental history, including research topics and questions, applied methodology, interactions with stakeholders as well as central results and data products. As such a database should exist in every research institution by its own right anyhow, it might merely be necessary to make explicit any historical aspects of previously conducted research.

Role models and networking

There exists a large variety of (European) databases, institutions and networks which scientifically cover different aspects of environmental history (see, for example, Table 1). This table is to be understood as a non-comprehensive collection of valuable benchmarks and potential partners in developing the attractiveness of eLTER RI to environmental historians and the broader socio-ecological research community. Networking approaches to scope for best practice examples and potential collaborative efforts are recommended.

Table 1: Selection of environmental history databases, networks and institutions to serve as a starting point for potential future networking approaches (list not comprehensive)

Name	Type	Description	Institution	Website
Euro-Climhist	Database	Climate-historical database written and pictorial documents on weather and climate history using climatological and historical methods	University of Bern	https://www.euroclimhist.unibe.ch
Oeschger Centre for Climate Change Research (OCCR)	Research institute	Interdisciplinary research space that addresses the complex Earth System and its global response to perturbations in the past and the future.	University of Bern	https://www.oeschger.unibe.ch
Archives of rural history (ARH)	Digital archive, research institute	Umbrella structure for agricultural archives; Archiving and historiography on rural society	Independent institute	https://www.histoirerurale.ch
European Rural History Organisation (EURHO)	Research network, conference	The EURHO is a non-profit organisation concerned to promote the study of all aspects of rural history in Europe and beyond.	Non-Governmental Organisation	https://www.ruralhistory.eu
European Society of Environmental History (ESEH)	Research network	The European Society for Environmental History promotes the study of environmental history in all academic disciplines.	Registered society	http://eseh.org
ARCADIA, Explorations in Environmental History	Environment & Society Portal	Open-access, peer-reviewed publication platform for short, illustrated, and engaging environmental histories	Rachel Carson Center for Environment and Society	http://www.environmentandsociety.org/arcadia
OECD Library & Archives	Archive	Archive on resource politics starting 1947	OECD Research Centre	https://www.oecd.org/general/oecdarchives.htm
World Glacier Monitoring Service (WGMS)	Database, inventory	Worldwide collection of information about ongoing glacier changes initiated in 1894.	ISC (WDS), IUGG (IACS), UNEP, UNESCO, WMO	https://wgms.ch/
Environmental History Collections	Library collection	Collection of works on historiography and methodology, small collections of secondary monographs and reference works as well as a growing number of published primary sources.	The Institute of Historical Research (IHR)	https://www.history.ac.uk/library/collections/environmental-history
FHS Environmental History Bibliography	Database	The Forest History Society collections contain an extraordinary range of information about forest and conservation history, from prehistoric times to current events.	Forest History Society	https://foresthistory.org/research-explore/archives-library/environmental-history-bibliography-database/

4.1.3 Transdisciplinarity

Stakeholder engagement is an integral part of SES research. Participatory processes are ideally designed as iterative, adaptive, self-aware and monitored processes, linking knowledge production with policy and implementation (Holzer et al. 2019). Stakeholder integration can be divided into the three main phases of Co-design, Co-production and Implementation (Lang et al. 2012, Gingrich et al. 2016). Co-design assures integration of regional needs and interests into the research agenda, involving stakeholders in project development and having them “own” the research problems and solutions. Co-production includes all participatory processes aimed at collecting data and creating knowledge. Implementation involves dissemination and communication of results, formulation of action plans and policy recommendations and provision of training resources and education.

LTSER platforms acting as *boundary organizations* (Pohl, 2008; Gingrich et al., 2016; Harris, 2013) should thereby establish cooperation and trust with relevant regional stakeholders, identify and provide incentives, build, maintain and expand a stable network, provide researchers with access to the network and facilitate exchange between researchers and stakeholders.

A framework to guide harmonization of transdisciplinary processes can be driven by two over-arching questions: 1. What kind of stakeholder integration is needed for socio-ecological research? And 2. How can stakeholder integration be standardized and sustained across the eLTER RI? Four pillars address different aspects of these questions. While some of those aspects will be naturally distinct between different eLTSER platforms due to regional characteristics of the SES and individual sustainability challenges, the framework aims at standardization of processes and methods to ensure long-lasting collaboration with local stakeholders. This important role of eLTSER platforms as boundary objects is becoming increasingly important as a thematic service area "Synthesis for Actionable Knowledge" TSA_05 is developing within the eLTER RI. There is a strong link between platforms distributed across Europe with strong links to local/regional stakeholders and a currently developing central service that provides actionable knowledge for transformation.

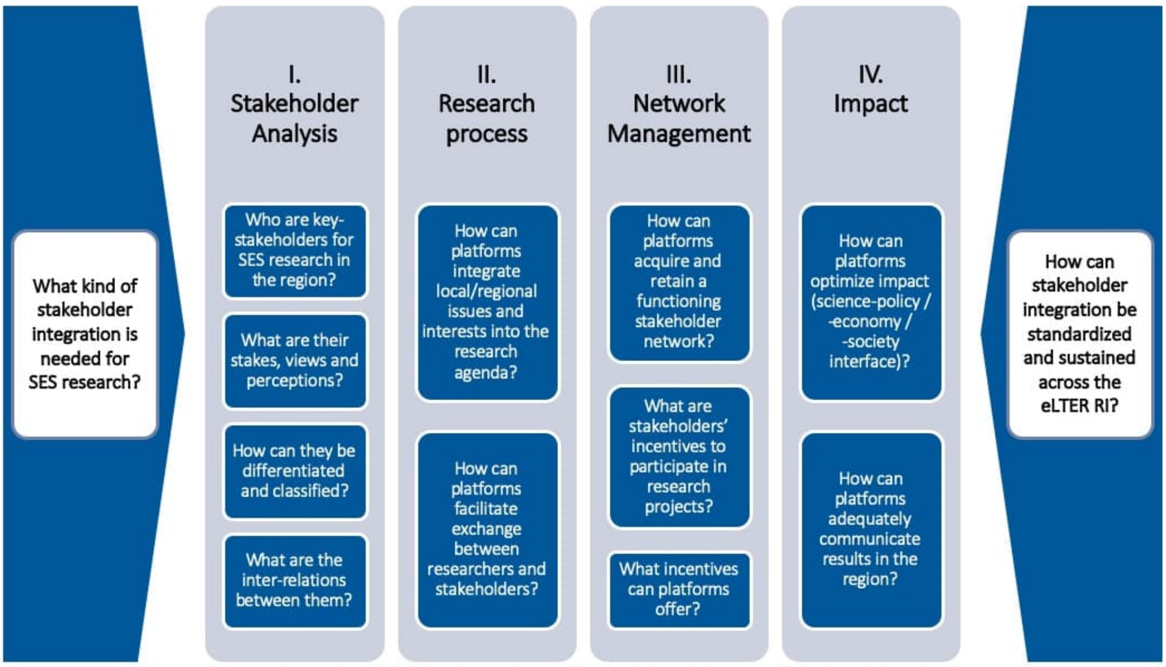

Figure 7: Framework to guide harmonization of transdisciplinary processes in eLTSER platforms

Conducting a preliminary stakeholder analysis is the starting point to identify and differentiate key regional stakeholders, their stakes and perceptions as well as the inter-relations between them. Relevant actors and their characteristics naturally depend on the research context and framing. The aim, nevertheless, is to create a proto-typical map of potential stakeholders relevant to the broad spectrum of socio-ecological research, particularly referring to the research themes outlined before. The research process itself involves two central challenges: a) integration of local and regional issues into the research agenda, and b) facilitating the exchange between researchers and stakeholders. On the platform level, stakeholder networks need to be managed continuously, understanding the stakeholders' motivation and creating incentives for participation, to acquire and retain over the long-term a functioning stakeholder network. Furthermore, platforms should actively design the science–policy interface and adequately communicate results to a broader society in order to maximize impact and encourage implementation.

Preconditions of successful collaboration (Krauze et al., 2018: eLTER H2020, D5.3) include interactive workshops, the strong role of an in-situ component and attachment of the stakeholders to the site, anchoring broad scale issues to local experiences enabling co-design, open sharing of knowledge, mutual learning, immediate feedback and sufficient funding.

4.1.4 Qualitative data management (QDM)

According to the inter- and transdisciplinary nature of socio-ecological research, many methodologies apply a mix of quantitative and qualitative data. While eLTER RI has extensive experience in managing quantitative data, the prospect of collecting, harmonizing, archiving and sharing qualitative data is a new challenge.

As qualitative data archiving and sharing is becoming more central to researchers, repositories as well as funding agencies, there exist a number of benefits, concerns and challenges. A major benefit is creating transparency and reproducibility in the social sciences, which have been criticized in this regard for a long time. The second major benefit is that archiving and sharing qualitative data enables its secondary use. Making qualitative data accessible and reusable thereby allows for posing new questions to existing material and as such may produce additional knowledge. The third major benefit relates to the compliance with funding or publishing requirements (FAIR principles).

Concerns include ethical issues to ensure participant protection, such as privacy, confidentiality and consent. Through necessary anonymization of data, however, integrity of data sets can be jeopardized. The process of documentation, annotation and creation of metadata is also very work-intensive and challenging for many researchers. Another concern relates to the lack of contextual knowledge, by which a secondary user's ability to effectively re-use existing material is hampered.

Challenges pertain to the granular nature of qualitative data, i.e. the fact that empirical claims are often backed by single pieces of data only (such as a short excerpt of a long interview). The context of data production needs to be sufficiently disclosed, as secondary data users often rely on in-depth conversation with original data producers. Significant factors for data reuse therefore include completeness, accessibility, ease of operation, credibility and documentation. Intellectual property for materials with third-party ownership (e.g. fixed in a tangible medium) can be a problem, and most researchers are aware of privacy but not copyright issues. Fair-use of qualitative data often allows for quoting portions of restricted length, but the best option may be to directly request permission from the data owner. From the viewpoint of secondary users, citation of the data repository or source as well as the data producer is often lacking or inaccurate.

A series of measures, which should be taken by repositories and researchers, help to guide the management of qualitative data to ensure their purposeful archiving and re-use (Karcher, Antes). Repositories should thereby collaborate with researchers. Researchers need repository guidance in creating documentation that contextualizes the data collection process as well as the resulting qualitative materials. This makes data intellectually accessible, useful for secondary users, discoverable and secure. Early data management consultation to plan for data archiving and sharing from the beginning of a research project facilitates the process. This follows the creation of a data management plan. From the researchers' point of view, beforehand preparation of consent forms to request copyright permission for archiving and sharing is advisable, because proves of permission (waiver) from research subjects to archive/share data are hard to obtain in retrospect, and it is unclear what options, if any, exist when old consent forms from past research state that data will not be used beyond the respective research project.

Many social science researchers take the default position of not wanting to share their data (while for some, the provision of excerpts from interviews is acceptable). This has to do with the above-mentioned concerns, in particular with the additional workload to researchers as well as the effects of secondary users lacking contextual knowledge. A way to effectively capture all expected details about the research process and methodology are so-called "data narratives", enabling a secondary user's understanding of the original research process, data and conclusions. Secondary data use should always create original value, the purpose has to be non-commercial and scholarly, the portion of material used is not substantial, and secondary use must not negatively affect existing markets for the original work.

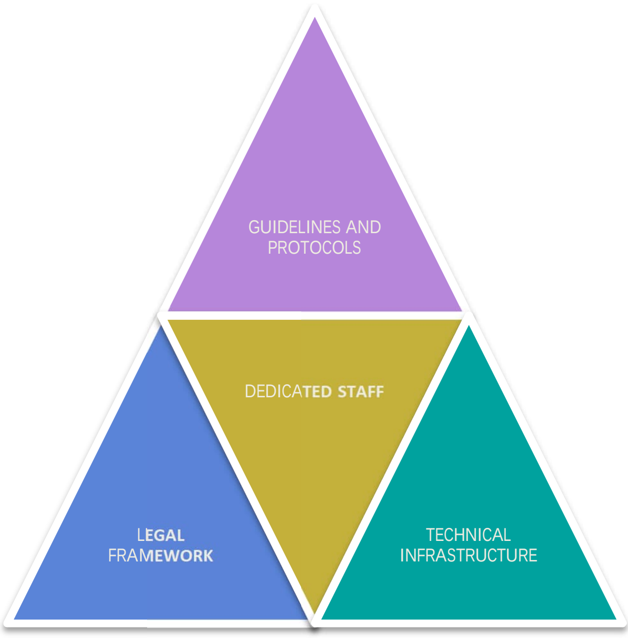

Figure 8: Potential cornerstones of qualitative data management in eLTER RI

In the light of these benefits, concerns and challenges, the management of qualitative data from participatory processes (i.e. harmonization, archiving, sharing) across eLTER RI is a challenge by itself. As highlighted in Figure 8, we propose QDM be based on a set of measures, actively integrating centralized with de-centralized services and activities. RI-wide measures would include a legal framework and data policy, as well as official guidelines and protocols for data producers and secondary users. A legal framework would comprise the definition of eLTER RI's data policy as well as specific data contracts for researchers using the RI's QDM services (for data collection/production, archiving/sharing, and secondary use). Data contracts ensure that researchers working with the RI to produce or reuse data (i.e. uses a platform's resources and networks) adhere to the RI's data policy (i.e. sign a data contract). Guidelines and protocols pertain to data-depositing (i.e. documentation, curation and participant protection) as well as secondary use (before/after data access). The RI furthermore needs to provide the technical infrastructure. Within eLTSER platforms, dedicated curatorial staff would be needed to facilitate archiving/sharing and secondary use of specific datasets. Platforms should also be able to offer flexibility in sharing data, given the nature of different types of research approaches. A platform's role must be equally pedagogical as technological. As guidelines are often unwritten and applied through exchange with repository curators, curators often act on a case-by-case basis, sometimes imposing additional requirements (underscoring the importance of dedicated staff). Guidance is also necessary at the outset of research planning and design.

Guidelines and protocols (Table 2) relate to data archiving and secondary use. Data archiving covers participant protection (anonymization, access control and permissions to archive and share) and documentation of methods, instruments, data quality and data gaps, codebooks, metadata and bibliography (with DDI compliance). Secondary use can be split into activities before and after data access. Before access guidelines describe how to formulate an application and explain aims and purposes of data re-use, set forth the research ethics as well as the requirements for permission from the data producer as well as conditions for restricted access. After access guidelines include regulations such as time limits, commercial use and redistribution rights, continued anonymity, rules for citation of data sources, accountability for new discoveries, sharing of new data sets resulting from secondary use as well as information regarding publication from reuse.

Table 2: Overview of content to be addressed in qualitative data management guidelines and protocols

Data archiving (depositing)	Secondary data use (sharing)
Participant protection • Anonymization • Access control • Permission to archive and share (obtain informed consent)	Before access • Describe application • Explain aims and purpose of use • Adhere to research ethics • Fulfill requirements for permission from data producer • Fulfill conditions for restricted access
Documentation • Methods • Instruments • Data quality and data gaps • Codebooks • Metadata • Bibliography • DDI compliance	After access • Time limit • No commercial use and redistribution • Required continued anonymity • Citation of data source • Accountability for new discoveries is on sec. user • Sharing of new data sets resulting from sec. use • Information on publications from reuse

Role models and networking

There exist a number of international initiatives and standards for documentation, metadata and annotation of qualitative data. eLTER RI should actively adopt existing standards and link to ongoing initiatives in this field.

Table 3: Selection of qualitative data management initiatives, standards and archives

Name	Type	Description	Website
Data Documentation Initiative (DDI)	Standard	International standard for describing the data produced by surveys and other observational methods in the social, behavioral, economic, and health sciences	*https://www.ddialliance.org*

Consortium of European Social Science Data Archives (CESSDA)	Consortium	Brings together social science data archives across Europe, with the aim of promoting the results of social science research and supporting national and international research and cooperation.	*https://www.cessda.eu*
Dublin Core™ Metadata Initiative	Initiave	Organization supporting innovation in metadata design and best practices across the metadata ecology	https://www.dublincore.org
Annotation for Transparent Inquiry (ATI)	Initiave	New approach to transparency in qualitative and multi-method research in the health and social sciences; allows for the generation, sharing, and discovery of digital annotations across the web	https://qdr.syr.edu/ati/ati-initiative
Hypothesis	Initiative	A conversation layer over the entire web that works everywhere, without needing implementation by any underlying site.	*https://web.hypothes.is*

4.2 Land-use systems analysis

Socio-ecological land-use system profiles contain a synthesis of the data and knowledge from our top-down and bottom-up approaches. We first describe the study regions based on existing literature as well as ecological and socio-economic data. Then we describe the central themes identified in the qualitative content analysis of the semi-structured interviews related to sustainability challenges in connection with land-use and climate change. In a next step, we describe relevant land-use actor groups, discuss their positions in relation to these central challenges, and present insights into the structure of the social land-use network.

4.2.1 Study regions

LTSER Eisenwurzen

The Eisenwurzen region is situated at the rim of the Northern Limestone Alps in central Austria. The region has a rather fuzzy border mostly defined by a shared cultural identity characterized by a rich history of metal extraction and processing that was mostly discontinued during industrialization (Brodda & Heintel, 2009; Heintel & Weixlbaumer, 1998; Schuh & Sieghartsleitner, 1997).

The LTSER platform covers a diverse and heterogeneous landscape with a total area of 5.904 km2, stretching across 91 municipalities located in the three Austrian Federal Provinces Upper Austria, Lower Austria, and Styria, and an altitude range from 167 m a.s.l. in the north to 2.515 m a.s.l in the south. 80 % of the LTSER platform are part of the Northern Limestone Alps, 11 % of the area belong to the Northern Alpine Foothills and 9 % belong to the Central Alps (DEIMS). The topographic gradient ranges from the low-lying Danube basin in the north over hilly and montane grasslands and forests to the alpine peaks of the Gesäuse in the south. According to DEIMS, Limestone and Flysch are dominating, with huge layers of tertiary sediments occuring in the northern less elevated fringe of the region. The valley bottoms are predominantly covered by quaternary sediments. Rendsina and Ranker cover more than 50 % of the area, brown earth covers almost 25 % of the area, followed by raw soils (6 %), Pseudo-Gley (5.5 %), Podsols, alluvial soils and others.

Land cover is dominated by forests (> 60 %) and grasslands (c. 15 %) as well as smaller areas of intensive cropland in the north, interspersed with small to medium sized settlements in the valleys and flatlands, one significant remain of the former iron industry in the south and some industrial-commercial complexes in the north-east (Figure 9). Land use primarily consists of (i) mostly intensive and conventional arable and livestock agriculture in the north, where only small-scale forest islands remain; (ii) intensive as well as extensive grassland agriculture including the last remains of historic orchard meadows in the hilly and submontane landscape, with larger areas of mixed and broad-leaved forests; and (iii) mostly intensive grasslands in the valleys as well as increasingly abandoned extensive alpine pastures and meadows in the rugged south, where > 85 % are covered with forests of which a large share are coniferous (Draschan et al., 2003; Gingrich et al., 2013; Helga et al., 2005). With this, the platform covers a broad transect of topography and land use in Austria and is well suited to approach questions of sustainable agriculture and forestry in a broader socio-ecological context (Bertsch-Hoermann et al., 2021).

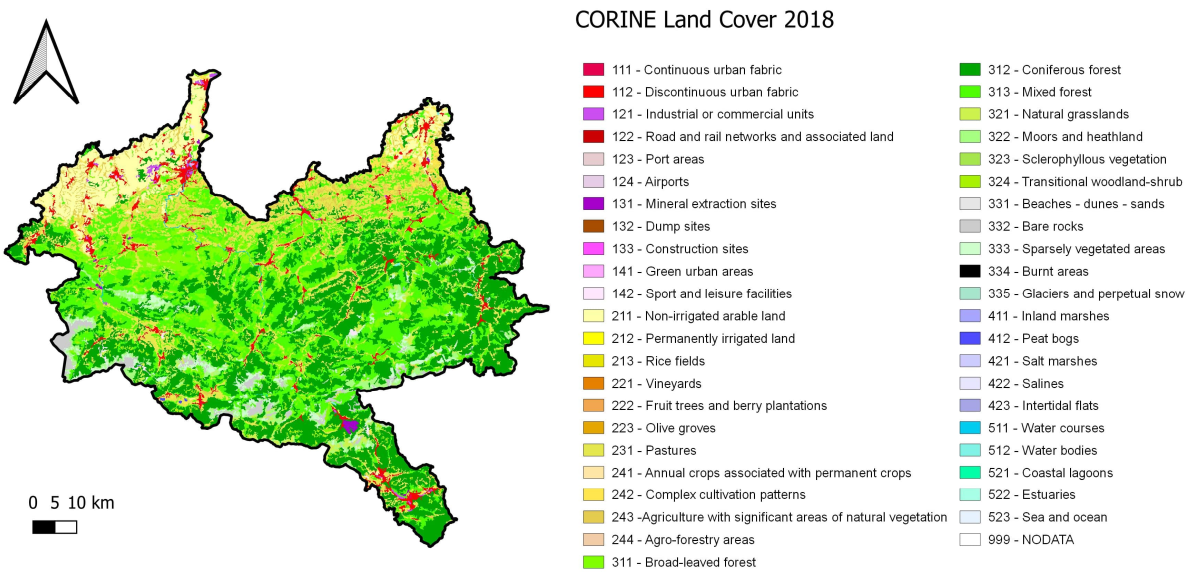

Figure 9: Boundary of the LTSER Platform Eisenwurzen and CORINE Land Cover from the year 2018.

Land-use history during the 19th and 20th centuries can be distinguished by three main phases (Gingrich & Krausmann, 2018): (1) pre-industrial land-use intensification (1830–1914) is characterized by moderate agricultural growth based on increased biomass recirculation, declining wood harvest, and, probably, slightly declining energy returns on investments; (2) industrialization of land use and the green revolution (1918 to 1985) exhibits a substitution of labor by modern energy inputs, while livestock continued to rely greatly on domestic biomass; and (3) industrialized extensification and environmental awareness (1986–2010) features increasing energy efficiency due to declines in livestock numbers, a shift towards forestry, and a rising amount of final products from croplands at stable energy inputs. Studies from the area focusing on the more recent past show the effects of land abandonment on vegetation and resulting shrub encroachment, even affecting the national parks within the region (Dirnböck et al., 2003). Two main contrasting trends are taking hold on agricultural lands: land abandonment and woody encroachment as well as afforestation takes place on marginal lands, whereas land-use intensity increases in flat areas with higher quality soils (Dullinger et al., 2020; Haberl et al., 2009).

Tourism increased strongly in the second half of the 20th century with the construction of roads and train connections, hiking and alpinism infrastructure as well as ski resorts (Dutzler, 1998), resulting in new pressures for the region's biodiversity (Haberl et al., 2009). Beyond local developments various external drivers affect the region's socio-ecological system, such as national and supranational regional and agricultural policies, developments of the subsidy regime and European CAP, changes in prices of energy and agricultural products as well as other socioeconomic trajectories such as migration, economic growth, development of tourism, or bio-energy policies (Haberl et al., 2009).

"The dependence of the Eisenwurzen on forestry, agriculture and tourism as main sources of income makes it vulnerable to climate change. Species adapted to living in high mountain areas are at risk of losing their ecological niches and going extinct, with negative effects on native species richness (Grabherr et al., 1994; Pauli et al., 2003). In combination with other pressures, this could affect the composition of habitats and ecosystems and therefore also the character of the landscape. Climate change increases the risk of disastrous weather phenomena, as mountain areas are vulnerable to periods of persistent heavy rainfall or snowfall that result in the flooding of settlements and agricultural land in the valleys and endangerment by mudflows and avalanches." (Haberl et al., 2009)

Depending on requirements and inputs from Task 8.5 to advance the cross-disciplinary synthesis and WAILS we intend to conclude this section ex post with a series of quantitative variables such as statistical data relating to agriculture and forestry, socio-economy and demography. One exemplary dataset of interest is a forest damage time series covering 20 years between 2002–2021 available at a spatial resolution similar to NUTS3 (Figure 10). The data is collected by Austrian county forest inspections. The three most relevant forest disturbance regimes are bark beetles, storms and snow. Damage due to avalanches, landslides and forest fires are reported in the data but omitted in the figures, because in comparison their extent is mostly irrelevant. The figure depicts aggregated data for all counties intersecting with the LTSER Eisenwurzen platform boundary and as such covers an area that is larger than the actual platform. Data can, if useful for Task 8.5 and WAILS, be disaggregated spatially in order to better fit individual LTER site boundaries (such as Zöbelböden, which falls into the county of Steyr).

a) b)

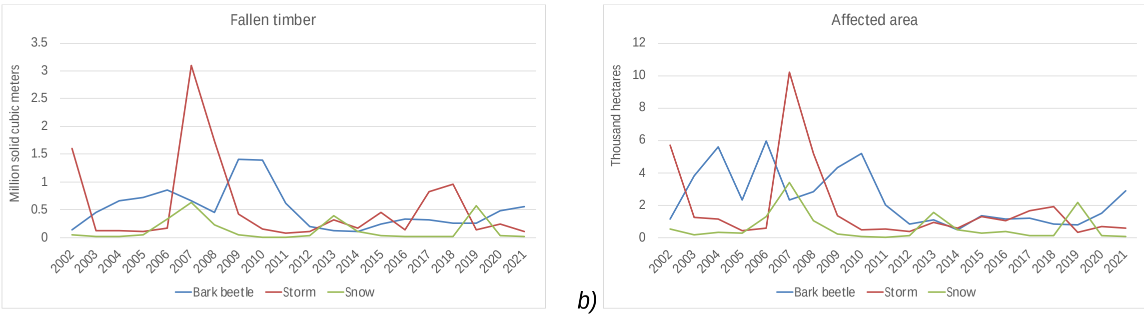

Figure 10: Damages from main forest disturbance regimes in the extended Eisenwurzen region (counties of Amstetten, Scheibbs, Gmunden, Kirchdorf/Krems, Steyr, Bruck-Mürzzuschlag, Leoben, Liezen) expressed in [a] fallen timber and [b] affected area, 2002–2021.

LTSER Doñana

LTSER Doñana is located in the south-west of Spain and primarily consists of a system of marshes, dunes, and beaches extending along the coastal plain of the Gulf of Cadiz at the Guadalquivir river mouth, holding the tributary streams that bring fresh water to the fluvial marshland. It covers an area of 2.736 km^2 including the protected area as well as the surrounding territories with a complex landscape matrix composed of rice fields, fisheries, irrigated crops, berry greenhouses, vineyards, olives and pine afforestations (DEIMS). Inside the protected land, the main 3 ecosystems sustain more than 1.550 species of vascular plants, 900 species of arthropods, up to 400 breeding and migratory bird species, 38 mammal species, 72 species of fishes, 40 reptile and amphibian species (DEIMS; ICTS Doñana Biological Reserve). The Greater Fluvial–Littoral Ecosystem of Doñana comprises four main ecodistricts: marshes, aeolian sheets, coastal system, and the Guadalquivir Estuary; and is a major stepping-stone in the migration route for birds, home to the Iberian lynx (Lynx pardinus), as well as many endemic and threatened species (Martín-López et al., 2011).

The region comprises the Doñana National Park (537 km^2), which is a Unesco Bioshere Reserve, a Ramsar Site and Natural World Heritage Site (DEIMS). The National Park was declared in 1969 by the

Spanish Government, and in 1989, its surroundings were declared a Natural Park by the Andalusian Government (Martín-López et al., 2011). The Doñana National Park is strictly protected, and only a few types of low-intensity traditional activities are allowed. The Doñana Natural Park was initially created to buffer human impacts on the National Park, and different traditional practices are allowed there (i.e., forestry, cattle ranching, game hunting, and agriculture in some areas). In 2005, the two Parks were unified under the protection status of a Natural Protected Area.

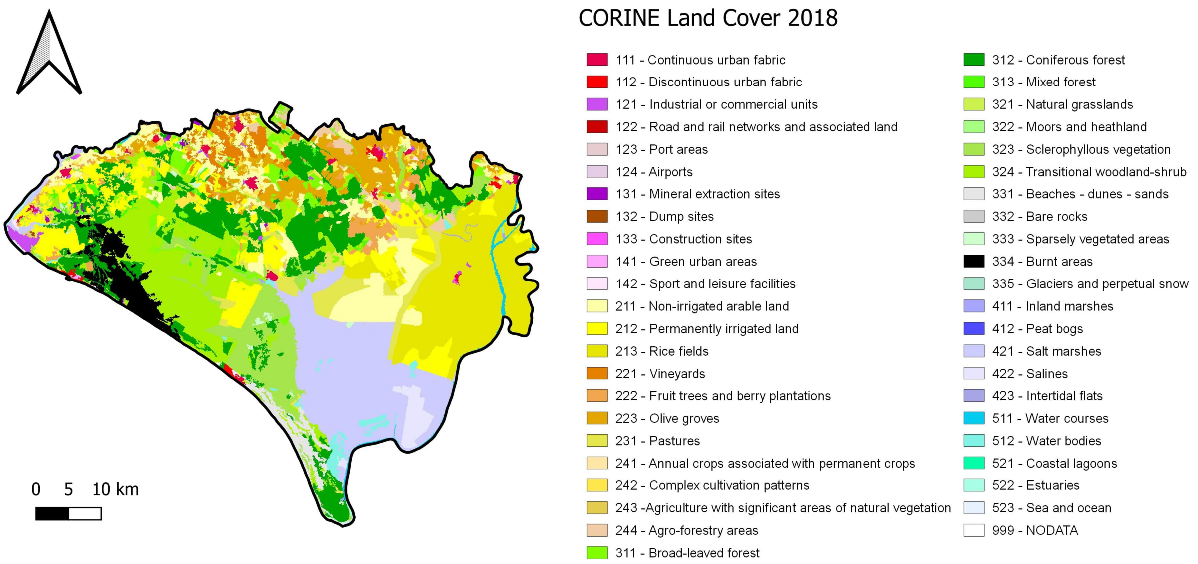

Figure 11: Boundary of the LTSER Platform Doñana and CORINE Land Cover from the year 2018.

Ecosystem services provided in this area cover a wide range of provisioning services (agriculture, cattle grazing, livestock (food), fishing (estuary and marshes) and shell fishing (coastal), hunting, fresh water, forest resources, pine cone harvesting, bee keeping), regulating services (air and water purification, water regulation, carbon sequestration, soil fertility, erosion control, micro-climatic regulation), supporting services (habitat for species), as well as cultural services (aesthetic values , environmental education and scientific knowledge, nature tourism, beach tourism, satisfaction for biodiversity conservation, sightseeing, cultural tourism, and religious tourism) (García-Llorente et al., 2018; Martín-López et al., 2011; Palomo et al., 2011).

Land-use change played a central role in the transformation of the LTSER Doñana region. A large share (c. 70-80%) of the natural and semi-natural land cover (primarily consisting of marshland) has been converted to intensive agriculture and other mono-functional land uses, such as forest monocultures with fast growing species, during the last century (Zorrilla-Miras et al., 2014; Haberl et al., 2009). Land-use change was thereby driven by forestry, agriculture and tourism policies. In the 1960s and 70s, large scale development plans transformed over 100.000 hectares of marshland into irrigated arable lands and sought to increase tourism in the region, where today the permanent population of 2000 inhabitants in Matalascañas increases to 300,000 tourists during summer (Martín-López et al., 2011). Traditional farming practices have been increasingly superseded by intensive rice farming and berry greenhouses, becoming the most productive crops in the region (De Stefano et al., 2017; Haberl et al., 2009). These developments led to a fundamental trade-off in ecosystem services supply, increasing provisioning services such as cash crops and fibre at the expense of regulating services, in particular hydrological regulation, flood buffering and habitats for species (Zorrilla-Miras et al., 2014).

The most important regional threats are overharvesting of groundwater and contamination due to intensive agriculture in the surroundings of the protected area, threatening the freshwater provision for the marshlands with important implications for biodiversity, as well as the local population (García-Llorente et al., 2018; Palomo et al., 2011). Water use conflicts have been intensifying during the last several years due to the rice farming sector (De Stefano et al., 2014, 2017) as well as the growing influence of intensive berry greenhouse agriculture, which is partly established on illegal lands, as well as intensifying drought pressure caused by climate change. In our qualitative analysis we thus focus on these factors and the ensuing land-use conflict

There exists a wide range of local stakeholders, which have been divided into groups (Villamor et al., 2014) with (1) local ecological knowledge, (2) policy ecological knowledge and (3) scientific knowledge. Group (1) contains farmers, livestock raisers, hunters, and honeybee keepers; group (2) contains managers from the protected area, administrators from the municipalities, regional water agency, regional environmental office, local sustainability agency, NGO representatives, environmental education professionals, representatives of the private sector related to tourism, and journalists; and group (3) contains researchers from different universities and research centers. Concerning stakeholders' relevance for climate change adaptation, actors whose livelihood depends on water availability, such as rice growers and fish farmers, are critical since they have high influence and high interest; regional policy makers are the context setters with high power but lower interest; and environmental groups have high interest but low power (De Stefano et al., 2017).

LTSER Braila Islands

LTSER Braila Islands is located in the South-East of Romania and covers an area of approx. 2.600 km^2 along the Danube between the cities of Hârșova and Brăila (RCSES, 2021). The socio-ecological system of the LTSER platform Braila Islands is characterized by anthropogenic as well as natural landscapes: it holds heavily modified ecosystems such as the Big Island of Braila, which is a former wetland that was transformed into agricultural land, as well as natural ecosystems such as the Small Islands of Braila (DEIMS). Wetlands include the Small Islands of Braila wetlands (along a Danube river stretch of 62 kilometers covering c. 210 km^2 with a set of 10 islets and a network of river arms and channels), as well as flood plains between riverbanks and dikes (covering c. 93 sq km). Vegetation in the floodplain is dominated by deciduous native forest, wetland (mire) and open grassland, often accompanied by alluvial soft wood forest, meadow and reeds, with 221 species of plants including aquatic associations. (RCSES, 2021). The area contains nine EUNIS level 1 habitats covering aquatic (wetland, river), terrestrial (grasslands, forests) as well as socio-economic systems (agroecosystems, human settlements, infrastruture) (Cazacu et al., 2015). These ecosystems provide a wide range of ecosystem services including provisioning services such as crop and animal production, fish and timber, angling, hunting, aesthetic value, recreation, water filtration, flood protection, nutrient retention, climate regulation and biodiversity-rich habitats (Grizzetti et al., 2016). In the current state provisioning services have the highest priority due to human intervention. Investments and running costs required to sustain the current state (such as maintenance of forest plantations and suitability of agricultural land, as well as irrigation, fertilizers etc.) decrease the total benefits for humans in comparison to the reference state (Cazacu et al., 2015). An area covering 205 km^2 are recognized on an international level as Ramsar site, Special Protected Area and Special Conservation Interest and on national level as Natural Park (Cazacu et al., 2015). Conservation objectives changed during EU accession from conventional protection of particular endangered species/taxons at small scales to conservation of biological diversity, ecosystems and land-waterscapes; the reduction of diffuse and point pollution and eutrophication; the restoration of structural configuration of the landscape; the sustainable use of ecosystem services; as well as the sustainable management of natural resources according to international and European conventions, strategies and directives (Geamana, 2014).

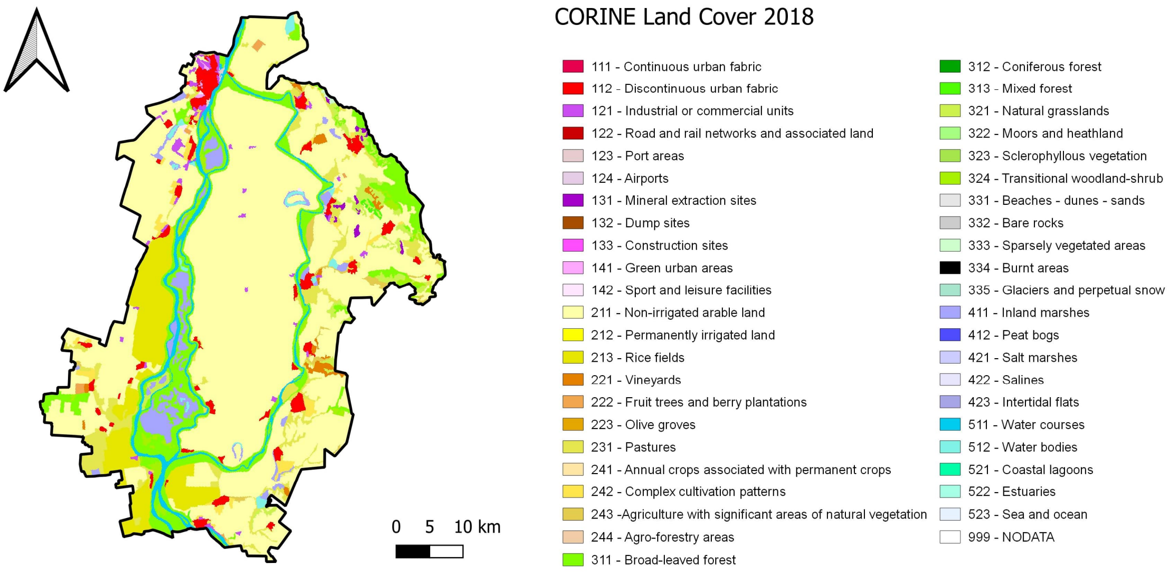

Figure 12: Boundary of the LTSER Platform Braila Islands and CORINE Land Cover from the year 2018.

Before the 1950s, the area was strongly dominated by linked wetlands such as shallow lakes and marshes (40%) as well as temporary flooded areas for the duration of 3-7 months (40%) down to a couple of weeks per year (20%) (Vadineanu et al., 2003). Collectivization processes after World War II led to increasing pressures on the ecosystems through conversion of diverse natural ecosystems in the Danube delta into agricultural land. These conversions made the ecosystems more vulnerable to anthropogenic and climate change pressures, leading to 70% of the region's total NPP directly being used by humans as intensively cultivated crops and livestock; fish catches falling below 1 kt/yr.; nutrient retention capacity falling below 5 kt N/yr and 0.25 kt P/yr; flood detention capacity decreasing to c. 1.8 km^3 of water; habitat fragmentation or destruction as well as eutrophication leading to dramatic biodiversity loss (Buijs et al., 2006; Haberl et al., 2009).
Stakeholders in the socio-ecological system of Braila Islands, in particular referring to biodiversity conservation, include individual households, local authorities, county and regional governing bodies, farmers and fishermen (individuals and associations such as the Al. Borza Foundation, Stancuta Fisherman Association; Braila County Association of Hunters and Anglers), mining and other industries, services provider companies, scientists, educators, nature conservation NGOs and associations (such as the Romanian Nature Admirers Association), commune councils, and the Small Wetland of Brăila natural Park (Geamana, 2014; Grizzetti et al., 2016). Authorities and governance stakeholders can be distinguished into central and regional stakeholders including the Ministry of Agriculture, Ministry of Environment, National Company for Land Reclamation, Romanian Water Administration, South-East-Regional Development Agency, National Environmental Agency; as well as county and municipal stakeholders including the Brailia County Council, Braila County Gouvernment, Romsilva Braila, Stancuta Local Council, and Braila Environmental Protection Agency (Geamana, 2014). Science stakeholders include the Antipa Natural History Museum Science Museums, National Research Institue of Soil & Agrochemistry, Forest Research & Management Institute, National Institute of Hydrology, University of Bucharest, Romanaian Academy (Geamana, 2014).

In the course of creating the socio-ecological profiles of the study regions we tested the 'Cookie cutter' app. We used the app to cut data from CORINE Land Cover 2018 to the platform boundaries of LTSER Eisenwurzen. From a socio-ecological perspective, the tool is very useful particularly for researchers who are not trained in GIS or who do not have access to GIS tools and software, which might rather be the case for social science rather than natural science researchers. The resulting map can then be used to spatially describe the given aspect of a region, which might be very helpful when looking to visually analyse certain data or creating a study region profile for a publication. Any manipulation, calculation or statistical analysis of a dataset that can be performed with a GIS software can, of course, not be performed with this tool, which limits its applicability for more advanced applications. As we are trained in GIS and do have access to GIS software, this was a mere test of the app's functionality. The interface was simple and intuitive and the app performed this task as it should. Concerning the usage with non-gridded data we have a more critical perspective on its applicability. If tabular data, such as population density, is available in a relatively good resolution, for example higher than NUTS 3 level, the app can be very useful to create a map and visualise differences between certain areas of a region, or to display spatial developments over time. If the data is, however, only available in a spatial resolution lower than NUTS3 (maybe even at level of NUTS1 or the national level), the app uses an algorithm which allocates a given value according the area ratio of the region to the dataset's spatial unit. In our view, this is only very crude approximation to reality. Let's take for example a population dataset available at the NUTS2 level. While the LTSER platform might be located in a rather remote part of the province the biggest share of the population might live in the province's one or two large cities outside the platform boundary (as is the case with LTSER Eisenwurzen). The app, however, will allocate population to the platform's boundary according to its share in the province's total area, potentially creating a very warped and unrealistic map. It lies, of course, within the user's responsibility to discern such potential fallbacks and refrain from the app's use if data were to be changed in a way harmful to the research process. We still feel that using the app with non-gridded data at lower spatial resolution (below NUTS3) warrants further development of the algorithm involved.

4.2.2 Preliminary results for LTSER Eisenwurzen

Stakeholders

Content analysis of the expert interviews allowed us to identify 142 land-use stakeholders and stakeholder groups across the whole land-use sector in the Eisenwurzen region (Annex C). Due to the nature of the open-ended questions and ensuing discussions during the interviews, respondents equally referred to broad stakeholder groups (such as land owners or processing industry) as well as to very individual stakeholders (such as naming specific land owners or retail businesses). To ensure comparability across interviews and to allow for consistent interpretation, we decided to allocate stakeholders to the most important sectors (Annex D, Annex E). We then allocated them within each sector into a number categories such as land owners and managers, consulting, lobbying or nature protection. Some stakeholders were thereby assigned to more than one sector and/or stakeholder group, as their scope of operation can stretch across sector or group boundaries, for example 'small-scale, family-run businesses' which might operate in the agriculture, forestry and tourism sectors at the same time, or the chamber of agriculture which is consulting farmers and foresters as well as representing their interests politically.

The most central stakeholder group are the land users themselves. Respondents identified several sector-specific sub-groups of land users and used certain characteristics to differentiate this relatively broad group. The characteristic most often referred to relates to the area extent owned or managed by a land user. In the agricultural sector these were small-scale family-run businesses, small and medium sized farms and large land owners. Large land owners were often identified as either being aristocratic families or the Admont Monastery, one of the largest private land owners in the region. A second characteristic that was used to differentiate land users was their mode of operation in terms of full-time or part-time. This differentiation is important because many family-run businesses cannot be sustained by the agricultural practice alone but require additional income from other, often non-farming occupations. In addition, one relevant sub-group are farms that simultaneously operate a tourism business typically called 'holiday farm', which is a common diversification strategy in the region to generate additional on-farm income. Another sub-group, which was explicitly mentioned, are 'newcomers' to the farming sector. In the forestry sector, size was the most important criterion for differentiation. Corresponding to the regions forest property structure, most forest owners identified are large land owners. These are, on the one hand, public owners such as the Federal Forests Austria (ÖBF), state forests owned by the Austrian provinces such as the Styrian State Forests as well as the City of Vienna. Most of the protected areas in the region, such as the National Park Kalkalpen, the National Park Gesäuse (both IUCN Cat. II) and the Wilderness Area Dürrenstein-Lassingtal (IUCN Cat. Ia/Ib) belong to these public owners. On the other hand, large private land owners were again identified as either being aristocratic families or being part of the church, specifically the Admont Monastery and the Archdiocese of Salzburg. Small-scale forest owners were often referred to as mixed forest-farms, a characteristic that is valid for many small and medium sized farms across Austria. Another group of small-scale forest owners were identified as so-called 'remote' or 'urban' forest owners who are characterized by the fact that they primarily own forests due to investment reasons without much interest or activity concerning the actual forest management. The forestry sector is additionally characterized by a number of land managers, who are not the owners themselves. This corresponds primarily to publicly owned land where official forest rangers and hunters play an important role, and, additionally, the protected areas where certain management structures and advisory panels are in place.

Another important stakeholder group is that of extension and consulting services. The most relevant actor in this group is the chamber of agriculture, operating at the level of federal provinces as well as more locally with their regional subsidiaries called district chambers. The chamber of agriculture is responsible for both the agriculture and forestry sectors and it was by far the most often discussed stakeholder in the context of extension and consulting services. The main activities of the chamber of agriculture and its subsidiaries are, by law, the official representation of interests of and consultation to farmers and foresters. Relating to the agricultural sector, the only other relevant stakeholder in this group mentioned during the interviews was BIO-Austria, which is the official representation of interests and consulting organization for organic farming. This first categorization already shows that consulting and lobbying are closely tied to each other. When discussing the forestry sector, interviewees identified a number of additional stakeholders including on a public level the district forest inspections, district rangers and forest authorities, as well as private forestry consultants.

As mentioned above, consulting and lobbying are, in part, closely tied to one another. Main stakeholders in the lobbying group are the chamber of agriculture and Bio-Austria, as well as land owner associations, political interest groups that are directly tied to the political parties, conservation NGOs including the 'Natural Forest Network', alpine associations, tourism associations and other civil society groups representing recreational interests.

Due to the number and extent of protected areas in the region, the conservation sector plays an important role in the local land-use system and is connected to many different other stakeholder groups. The main direct conservation actors are the National Park Kalkalpen, the National Park Gesäuse, and the Wilderness Area Dürrenstein-Lassingtal, as well as the Styrian Eisenwurzen Nature & Geopark, Lower Austrian Eisenwurzen Nature Park and Ötscher Tormäuer Nature Park. As described above, the national parks and wilderness area have public land owners, while the nature parks stretch across cultural landscapes with multiple public and private land owners. Both categories have strictly defined conservation objectives and additionally engage in tourism, but nature parks also strive to protect and develop valuable cultural landscapes in connection with their land-use and management aspects. This approach encompasses not only conservation and recreational/touristic uses, but also focuses on regional and rural development including the creation of additional jobs in the land-use sector. Other important players in this regard are, on the one hand, regional development initiatives such as the LEADER regions or the National and Nature Park Partners, which also strive to support sustainable rural development, and, on the other hand, a range of conservation NGOs (i.e. the Austrian League for Nature Conservation, Friends of Nature Austria, World Wildlife Fund, Mollner Kreis) as well as the Natural Forest Network (which works with local stakeholders to implement connecting corridors between the protected areas) and LUKA (Arbeitskreis Luchs OÖ), a regional initiative for protection of the Lynx. Important actors in the field of politics and conservation are, besides the federal government, the three provincial governments and parliaments (Landtag and Landesregierung) including their environmental secretaries (Landesrat für Naturschutz), as well as the municipalities. Nature conservation in Austria is regulated by the nine Austrian federal provinces, resulting in nine distinct nature protection laws as well as distinct implementations of the EU Habitats Directive, the Water Framework Directive and the Bird Directive. As conservation objectives also create conflicts between different land users, there exist local initiatives to tackle important issues, for example the behavior of certain tourist groups (e.g. mountain bikers) inside protected areas by the National Park Bike- and Hiking-Specialists. In the educational sector, conservation actors are primarily the National and Nature Park Partner Schools and rangers.

We will discuss the most relevant stakeholders in the context of power and dependency, land-use conflicts, climate change impacts, risk awareness and adaptation. On this basis we will assess the choice of actors to be implemented subsequently in the agent-based model. Analysis is planned to be finalized by July 2023.

Social network analysis

Results from the social network analysis reveal insights about the land-use related communication between actors. We thereby required respondents to allocated their most important communication partners to a predefined set of stakeholder groups, specify their communication frequency with each partner (differentiated by a range of land-use related topics), as well as to assess the influence of this communication on the respondent's decision-making. Additionally, we collected a series of demographic and farm-related variables.

The network graphs presented in

Figure 13–Figure 15 are first drafts to depict the connections between actors.

Figure 13 and Figure 14 show aggregated connections between actor groups and Figure 15 disaggregated connections between individual actors. Figure 13 visually reveals those groups that are most interconnected with all other groups, whereby actor groups with the most diverse set of connections are small (< 50 ha) and large (> 50 ha) land users, protected areas, the chamber of agriculture and other public consultants. While the chamber of agriculture is not connected to a large number of different groups, it communicates with the largest number of individual small and large land users at a relatively high frequency. Figure 14 shows the average influence of the communication on decision-making (depicted by edge color). The data, for example, reveals that communication with the retail actor group has the highest average influence on small land users' decision-making. Furthermore, it shows that protected areas are highly influenced by its communication with the local population, large land users and the chamber of agriculture. Interestingly, many land users also replied that they not only receive but also provide relevant information to the chamber (which is not represented in the network graphs, at this stage). These insights already point to the chamber's importance as a regional information hub and might warrant this group to be implemented as an active actor in the agent based model. This is further backed by the fact that many survey respondents allocated themselves simultaneously to one of the two land user groups and the chamber of agriculture. Protected areas also play an important part in the regional land-use social network. Although their communications are not as frequent, they are the third most connected group and communicate with most of the other actors. Disaggregated connections (Figure 15) additionally reveal intra-group communication. Data for example shows that small land users communicate much more with their group, than other actor groups do.

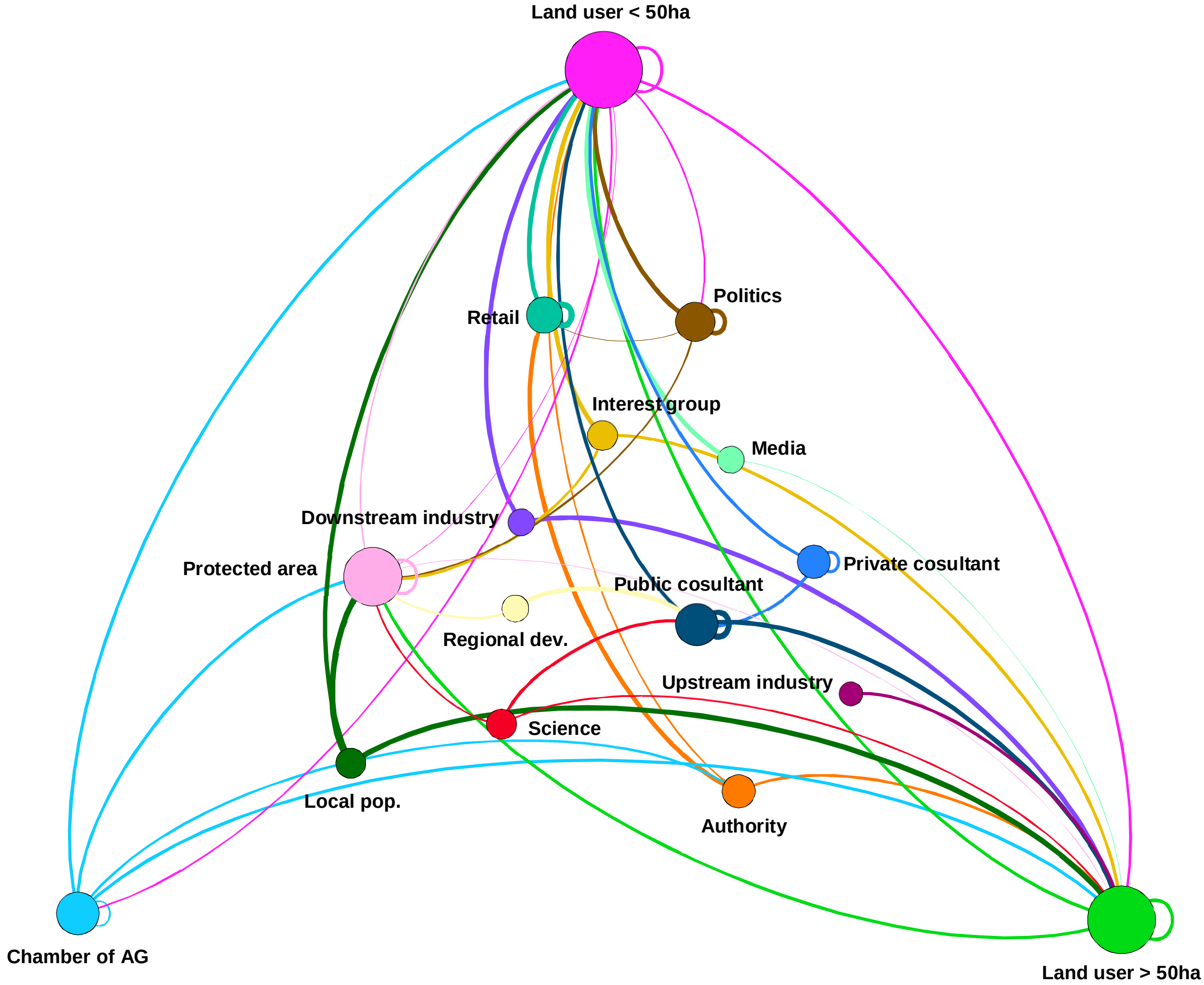

Figure 13: Network graph of land use actor groups in LTSER Eisenwurzen. Nodes depict aggregated actor groups; node size depicts an actor group's degree (i.e. the number of incoming and outgoing connections); edges depict connections between actor groups; edge colour depicts the direction of the information flow (corresponding to the source of information); and edge weight depicts the frequency of communication (thicker lines represent higher frequency).

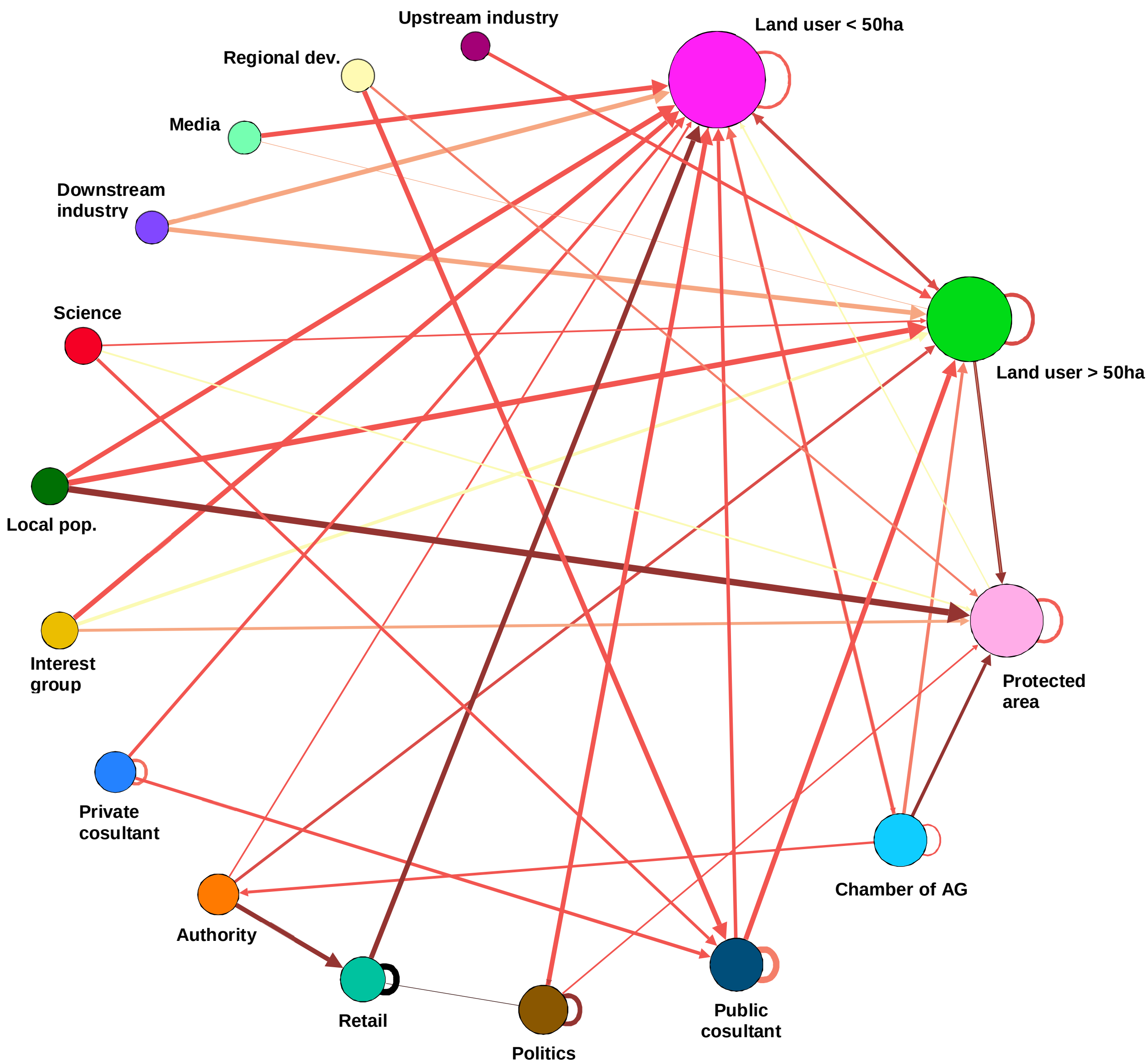

Figure 14: Network graph of land use actor groups in LTSER Eisenwurzen. Nodes depict aggregated actor groups; node size depicts an actor group's degree (i.e. the number of incoming and outgoing connections); edges depict connections between actor groups; arrows depict the direction of the information flow (corresponding to the source of information); edge weight depicts the frequency of communication (thicker lines represent higher frequency); and edge colour depicts the influence of the communication on land-use decision making (darker lines represent higher influence).

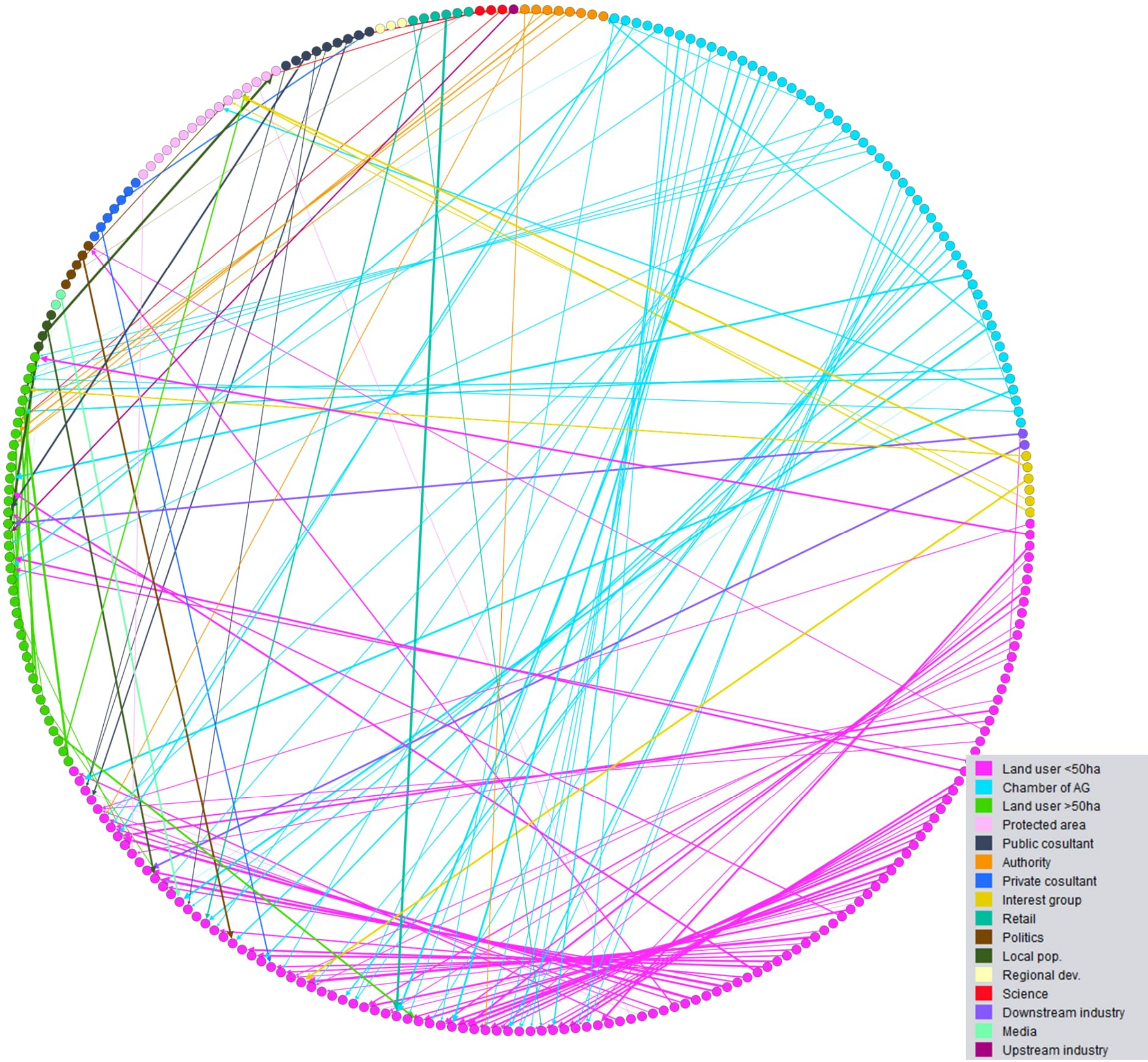

Figure 15: Network graph of land use actors in LTSER Eisenwurzen. Nodes depict individual actors; edges depict connections between actors. Arrows depict direction of information flow, arrow weight depicts frequency of communication (thicker lines represent higher frequency).

As the online survey in LTSER Eisenwurzen was terminated very recently (Jan. 2023), data processing and analysis is still work in progress. Analysis of the complete online survey dataset, a large part of which is not represented here, is planned to be finalized in conjunction with the stakeholder analysis by July 2023. The submission of a peer-review publication based on the analysis is planned for summer 2023. In addition, this analysis constitutes another building block informing development of the agent-based land-use decision model SECLAND (differentiation of active/passive actors, influence of social network on decision-making). A peer-review publication based on the analysis is planned for summer 2023.

5 Acknowledgements

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7 Annex

Annex A: Interview guideline used for the semi-structured expert interviews

1. What is your personal background, connection to the region, in which function, since when ... ?
2. From your point of view, what are the most important changes concerning land use in the region in the last c. 20 years?
3. Where do you currently see the biggest challenges for land-use in the region?

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4. Who are the most important stakeholders in the land system?
   (–> specific sub-systems, e.g. crops, livestock, grassland, forest etc.)

   a. What are their stakes?
   b. Key interests and objectives?
   c. Conflicting objectives with other stakeholders?
   d. Seeking change or maintaining status quo?
   e. Framework conditions, dependencies, scope for action?

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5. What are the major impacts of climate change in the region?
6. Which actors are particularly affected by these impacts?

   a. Do they perceive the risks?
   b. What adaptation measures are already taking place?

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7. Are there any other issues you want to add, or additional actors that play an important role?

Annex B: Questions of the social network analysis online survey (example of Eisenwurzen)

Land use and climate change in the Eisenwurzen

This online survey is part of the eLTER PLUS research project conducted by the University of Natural Resources and Life Sciences, Vienna + 1 local institution. For further information please contact: bastian.bertsch-hoermann@boku.ac.at + 1 local contact person

Thank you very much for participating in this survey!

Your answers allow us to better understand land use in the Eisenwurzen region. In taking part, you will make an important contribution to our research on climate change impacts and adaptation strategies. The survey will take a maximum of 10-15 minutes of your time!

Privacy

Although we are collecting personal data, this survey is completely anonymous. Contact information can be provided voluntarily at the end, if you want to be informed about the results of this study. Data processing is subject to strict anonymization procedures and no data will be disclosed to third parties. All data are strictly protected by the European Data Protection Regulation.

* Required

1. In which municipality do you live? *
   - Liezen (East)
   - Liezen (West)
   - Kirchdorf
   - Steyr / Steyr Land
   - Linz-Land
   - Amstetten
   - Waidhofen a.d. Ybbs
   - Scheibbs
   - Other:

2. How old are you? *
   - < 25 years
   - 26-40 years
   - 41-55 years
   - > 55 years

3. What is your highest level of education? *
   - Compulsory education
   - Apprenticeship, skilled worker
   - Secondary school
   - University / college / academy
   - Other:

4. What is your gender? *
   - Male

- Female
- Other:

5.a To which of the following groups do you most closely associate yourself? *

- Land owner/manager (less than 50 hectares of cultivated land)
- Land owner/manager (more than 50 hectares of cultivated land)
- Chamber of Agriculture
- Other public consulting or educational institution
- Private consulting or educational service provider
- Political representation of interests
- Government agency, administration
- Politics
- National Park, protected area
- Research, science
- Tourism
- Regional development
- Environmental NGO or nature advocacy group
- Civil society, local population
- Upstream industry (e.g. retail of agricultural machinery, fertilizer, crop protection)
- Processing industry (e.g. dairy factory, slaughterhouse, sawmill)
- Retail (e.g. trade of agricultural and forestry products, super market, farmers market)
- Media
- Other:

5.b Optionally, please specify other groups that you belong to: *
(Multiple selection possible)

- Land owner/manager (less than 50 hectares of cultivated land)
- Land owner/manager (more than 50 hectares of cultivated land)
- Chamber of Agriculture
- Other public consulting or educational institution
- Private consulting or educational service provider
- Political representation of interests
- Government agency, administration
- Politics
- National Park, protected area
- Research, science
- Tourism
- Regional development
- Environmental NGO or nature advocacy group
- Civil society, local population
- Upstream industry (e.g. retail of agricultural machinery, fertilizer, crop protection)
- Processing industry (e.g. dairy factory, slaughterhouse, sawmill)
- Retail (e.g. trade of agricultural and forestry products, super market, farmers market)
- Media
- Other:

6. Do you own/manage a farm or forestry business? *

- Yes *(Continue with question 7)*
- No *(Skip to question 22)*

Section for farmers/foresters

7. Are you engaged in arable or horticultural farming? *

- Yes *(Continue with question 8)*
- No *(Skip to question 11)*

8. Please tick all categories that apply to your farm:
(Multiple selection possible)

- Cereals
- Field forage
- Oilseeds
- Roots and tubers
- Vegetables
- Wine
- Other fruits
- Other:

9. How much arable/horticultural land do you manage?

- < 20 hectares
- 20-49 hectares
- 50-100 hectares
- > 100 hectares

10. In arable and horticultural farming, do you apply any of the following measures in response to climate change impacts and risks? *
(Multiple selection possible)

- Artificial irrigation
- Rainwater collection / storage
- Glass house / polytunnel
- Conservation tillage / no-till
- Changes in sowing and/or harvesting dates
- Cultivation of other/new varieties
- Own research in new genotypes
- Renting of pollinators
- Diversification (increase in added value, e.g. processing of agricultural products, direct marketing, farm vacations)
- Increased pest management and monitoring
- Precision and/or satellite agriculture
- Weather forecasts and early warning systems
- Crop loss insurance
- Consulting by public organizations (e.g. Chamber of agriculture etc.)
- Consulting by private service providers and experts
- Education and training in climate change adaptation
- Funding for applied research projects targeting specific farming issues
- Other:

11. Do you have livestock? *

- Yes *(Continue with question 12)*
- No *(Skip to question 17)*

12. Please tick all categories that apply to your farm and add an approximate number of heads:
(Multiple selection possible)

- Cattle _____
- Pigs _____
- Poultry _____
- Sheep or goats _____
- Bees _____
- Fish _____
- Other: _____ _____

13. Are you engaged in pastoral farming? *

- Yes (*Continue with question 14)*
- No (*Skip to question 16)*

14. Please tick all pastoral farming categories that apply:
(Multiple selection possible)

- Pasture, extensive (1 LSU or less per hectare)
- Pasture, intensive (more than 1 LSU per hectare)
- Meadow, extensive (1-2 cuts per year)
- Meadow, intensive (3 or more cuts per year)
- Orchard meadow
- Other:

15. How much grazing and/or grassland do you cultivate?

- < 20 hectares
- 20-49 hectares
- 50-100 hectares
- > 100 hectares

16. In livestock and/or pastoral farming, do you apply any of the following measures in response to climate change impacts and risks? *
(Multiple selection possible)

- Addition of other/new animal breeds
- Cultivation of other/new grass varieties
- Change of grazing/mowing dates
- Change of grazing/mowing intensities
- Change of feed composition
- Rainwater collection / storage
- Structural changes to stables (e.g. roof structure, shading, ventilation openings)
- Air conditioning / water cooling (misting, evaporation) of stables
- Reduction of animal density
- Diversification (increase in added value, e.g. through processing of agricultural products, direct marketing or farm vacations).
- Precision and/or satellite agriculture
- Weather forecasts and early warning systems
- Crop failure insurance
- Consulting by public organizations (e.g. Chamber of agriculture etc.)
- Consulting by private service providers and experts
- Education and training in climate change adaptation
- Funding for applied research projects targeting specific farming issues
- Other:

17. Are you engaged in forestry? *
- Yes *(Continue with question 18)*
- No (*Skip to question 21)*

18. Please tick all categories that apply to your forestry enterprise:
(Multiple selection possible)
- Coniferous forest
- Deciduous forest
- Mixed forest
- Short-rotation plantation
- Agroforestry (trees and crop/livestock on the same unit of land)
- Other:

19. How much forest area does your farm manage?
- < 20 hectare
- 20-49 hectare
- 50-100 hectare
- > 100 hectare

20. In forestry, do you apply any of the following measures in response to climate change impacts and risks? *
(Multiple selection possible)
- Change of tree species composition
- Increased diversity of tree species
- Change of rotation period
- Increased thinning
- Increased use of natural rejuvenation
- Increased protection against game damage
- Increased pest management and monitoring
- More frequent controls and forest tours
- Reduced use of heavy harvesting equipment
- Forest fire prevention
- Weather forecasts and early warning systems
- Contribution to restoration programs by removal and eradication of invasive alien species
- Consulting by public organizations (e.g. Chamber of agriculture)
- Consulting by private service providers and experts
- Education and training in climate change adaptation
- Funding for applied research projects targeting specific farming issues
- Other:

21. Is your farm or forestry business run on a full-time or part-time basis?
- Full-time
- Part-time

22. How many people (including yourself and your family) work on your farm on average?
- 1-2
- 3-5
- 6-10
- > 10

23. Is your farm certified organic?
- Yes
- No
- Partial / In conversion

24. What were your average annual costs for fertilizer and crop protection during the last five years?
- < 88 € / hectare
- 88-560 € / hectare
- > 560 € / hectare

Personal network and communication

Landowners, land managers and other land-use experts usually communicate about specialist topics on a regular basis. With whom do you talk about relevant issues concerning land use and climate change? Please list your most important communication partners and answer the questions below.
(The following section is repeated once by default, and optionally a second time.)

Contact person 1 (2, 3)

25.a Please think about your most important contact person for issues concerning land use and climate change. To which of the following categories can you assign contact person 1? *
- Land owner/manager (less than 50 hectares of cultivated land)
- Land owner/manager (more than 50 hectares of cultivated land)
- Chamber of Agriculture
- Other public consulting or educational institution
- Private consulting or educational service provider
- Political representation of interests
- Government agency, administration
- Politics
- National Park, protected area
- Research, science
- Tourism
- Regional development
- Environmental NGO or nature advocacy group
- Civil society / local population
- Upstream industry (e.g. retail of agricultural machinery, fertilizer, crop protection)
- Processing industry (e.g. dairy factory, slaughterhouse, sawmill)
- Retail (e.g. trade of agricultural and forestry products, super market, farmers market)
- Media
- Other:

25.b Optionally, please assign contact person 1 to further groups: *
(Multiple selection possible)
- Land owner/manager (less than 50 hectares of cultivated land)
- Land owner/manager (more than 50 hectares of cultivated land)
- Chamber of Agriculture
- Other public consulting or educational institution
- Private consulting or educational service provider
- Political representation of interests

- Government agency, administration
- Politics
- National Park, protected area
- Research, science
- Tourism
- Regional development
- Environmental NGO or nature advocacy group
- Civil society / local population
- Upstream industry (e.g. retail of agricultural machinery, fertilizer, crop protection)
- Processing industry (e.g. dairy factory, slaughterhouse, sawmill)
- Retail (e.g. trade of agricultural and forestry products, super market, farmers market)
- Media
- Other:

26. What is your relationship with contact person 1? *
(Multiple selection possible)

- Family
- Friend
- Neighbour
- Advisor
- Business partner
- Employee
- Employer
- Other:

27. How often do you communicate with this person in the context of land use and climate change? *

- Daily
- Weekly
- Monthly
- 2-6 times per year
- Less than twice a year

28. How frequently do you communicate with this person about the following topics? *
(Selection of one option per line mandatory)

	Always	Often	Sometimes	Rarely	Never
Technical issues					
Marketing, diversification					
Crop damage, protection, insurance					
Finance, economy, prices					
Subsidies, politics, EU					
Climate change					
Water					
Biodiversity					
Sustainability					

29. How influential do you consider this person to be for your land-use decisions? *

- 1 Extremely influential
- 2 Very influential
- 3 Influential
- 4 A little influential
- 5 Not influential at all

30. Do you receive or provide information from/to this person? *
(Multiple selection possible)

- I receive information from this person.
- I provide information to this person.

(Repeat Q25-30 once, by default)

31. Do you want to add a third contact person?

- Yes *(repeat Q25-30)*
- No, finalize survey

Thank you very much for taking the time to complete this survey!

32. If you want to be informed about the results of this research project, please provide your email address:

31. If you want to offer any additional feedback, we would be pleased to hear from you:

We wish you a wonderful day!

Annex C: List of stakeholders of the land-use system in LTSER Eisenwurzen identified through expert interviews and their allocation to different sectors and stakeholder groups.

Stakeholders	Agriculture	Forestry	Conservation	Politics	Tourism	Cross-sector	Education	Industry
Admonter Holzindustrie AG		x						
Advisory panel (Kuratorium NP Kalkalpen)			x					
AG tech industry	x							
Alpine associations (ÖAV, DAV)					x			
Animal feed industry	x							
Aristocracy	x	x						
Automotive suppliers								x
Bio-Austria	x							
Biomass heating plant		x						x
BMW								x
Business park								x
Cattle exchange (Rinderbörse)	x							
Chamber of agriculture (Landwirtschaftskammer)	x	x						
Chamber of commerce								x
Children						x	x	
Church (Diözese)		x						
City of Vienna		x		x				
Civil societies						x		
Construction businesses								x
Consumers	x					x		
County administration (Bezirkshauptmannschaft)	x	x		x				

County construction administration (Baubezirksleitung)				x				x
Dairy cooperative	x							
Dairy factory	x							
Day tourists					x			
Diözese Salzburg		x						
Direct marketers	x							
Disposal facility								x
District chamber (Bezirksbauernkammer)	x							
District forest inspection (Bezirksforstinspektion)		x						
District ranger (Bezirksförster)		x						
Druckgusswerk								x
Eisenstrasse-Vereine						x		
Emergency organisations						x		
Envesta GmbH								x
EU	x	x		x				
Extension services, consulting	x	x						
Extractive industry								x
Farmers	x							
Farmers, full-time	x							
Farmers, part-time	x							
Farmner's union (Bauernbund)	x	x		x				
Federal Forests Austria (ÖBF)		x						
Federal state	x	x	x	x				
Fisheries						x		
Food Coops	x					x		

Forest authority		x						
Forest consultants		x						
Forest owners association		x						
Forest owners/managers		x						
Forest ranger		x						
Forestry representatives		x						
Forestry schools (Forstfachschulen)		x					x	
Forestry workers, small businesses		x						
Freight companies		x						x
Gravel pit								x
Green Party (GRÜNE)				x				
Hunters		x						
Industry								x
Klimabündnis-Gemeinden				x		x		
Land owner representatives	x	x						
Land owners	x	x						
Landesrat für Naturschutz	x		x	x				
Large businesses								x
Large forest owners		x						
Large land owners	x	x						
LEADER	x	x	x			x		
Local initiatives						x		
Local population						x		
Local representatives						x		
Logging company		x						
LUKA (Arbeitskreis Luchs)			x					

Mayor				x			
Media						x	
Mixed land users, grassland/forestry	x	x					
Mollner Kreis			x				
Municipality (Gemeinde)	x	x	x	x			
National park management		x	x		x		
National park partner			x				
National park schools			x				x
National parks		x	x		x		
Nationalpark Bike-Spezialisten		x	x		x		
Nationalpark Wander-Spezialisten	x	x	x		x		
Natur- und Geopark Eisenwurzen		x	x		x		
Nature park partners			x		x		
Nature reserves			x		x		
Nature-loving tourists					x		
Naturfreunde	x	x	x				
Naturpark Schools			x				x
Naturschutzbund	x	x	x				
Netzwerk Naturwald		x	x				
Newcomers (Quereinsteiger)	x						
NGOs	x	x	x				
NP Gesäuse		x	x		x		
NP Kalkalpen		x	x		x		
Nurseries (Baumschulen)		x					
Older people						x	
Operations manager (agriculture, forestry)	x	x					

Paper factory								x
People's Party (ÖVP)				x				
Pig exchange (Schweinebörse)	x							
Plastic industry								x
Political represenattion of interests (lobbying)				x				
Private businesses								x
Private cattle traders (Kuhhändler)	x							
Processing industry	x	x						
Purchasing community (Einkaufsgemeinschaft)	x							
Regional businesses								x
Regional developers						x		
Regional newspapers						x		
Researchers	x		x			x		
Retail	x							
Retail networks	x							
Sawmill		x						
Schools							x	
Second home owners						x		
Sector unions				x				
Sewage plant								x
Skiing resorts					x			
Slaughterhouse	x							
Small and medium sized farms	x							
Small forest owners		x						
Small hydro power plants						x		
Small-scale, family-run businesses	x	x			x			

Social Democrats (SPÖ)				x			
State forests (Landesforste)		x					
State government (Landesregierung)			x	x			
State parliament (Landtag)			x	x			
State parliament delegate (Landtagsabgeordneter)			x	x			
Steiermärkische Landesforste		x					
Stift Admont	x	x			x		
Stiftsgymnasium							x
Timber construction (Holzbau)		x					
Tourism associations					x		
Tourism businesses					x		
Tourists					x		
Upstream industry	x	x					
Urlaub am Bauernhof	x				x		
Wildnisgebiet Dürrenstein		x					
Wood industry		x					
WWF	x	x	x				
Youth						x	

Annex D: Stakeholders of the agricultural sector

Land owners/managers	Downstream	Upstream	Retail sector	Consulting	Lobbying	Policy/Regulations/Subsidies
Farmers	Processing businesses	Animal feed industry	Food Cooperatives	Chamber of agriculture	Land owner representatives	European Union
Farmers, full-time	Dairy factory	Purchasing community (Einkaufsgemeinschaft)	Retail businesses	District chamber	Political interest groups	Federal state
Farmers, part-time	Slaughterhouse	Upstream businesses	Direct marketers	Bio-Austria	Farmer's union (OEVP)	Govenor for nature protection
Mixed farms	Dairy cooperative	AG tech industry	Retail networks		Green Farmers (GRÜNE)	County administration (Bezirkshauptmannschaft)
Small and medium sized farms	Pig exchange (Schweinebörse)		Consumers		Social Democrats (SPÖ)	Municipality (Gemeinde)
Family-run businesses					NGOs	Mayors
Holiday farms	Cattle exchange (Rinderbörse)				Naturschutzbund	
Career changers (novices)	Private cattle traders (Kuhhändler)				Naturfreunde	
Operations managers					World Wildlife Fund	
Large land owners					Bio-Austria	
Aristocratic families					National park hiking/biking specialists	
Stift Admont (monastery)						

Annex E: Stakeholders of the forestry sector

Land owners/managers	Downstream	Upstream	Consulting	Lobbying	Policy/Regulations/ Subsidies	Recreational use	Nature protection	Education/Science
Land owners	Forestry workers, small businesses	Nurseries (Baumschulen)	Chamber of agriculture (Landwirtschaftskammer)	Netzwerk Naturwald	District forest inspection (Bezirksforstinspektion)	Nationalpark Bike-Spezialisten	National park management	National parks
Forest owners/managers	Logging company		District forest inspection (Bezirksforstinspektion)	Nationalpark Bike-Spezialisten	District ranger (Bezirksförster)	Nationalpark Wander-Spezialisten	National parks	NP Gesäuse
Small-scale, family-run businesses	Freight companies		District ranger (Bezirksförster)	Nationalpark Wander-Spezialisten	County administration (Bezirkshauptmannschaft)	Alpine associations (ÖAV, DAV)	NP Gesäuse	NP Kalkalpen
Mixed land users, grassland/forestry	Processing industry		Forest authority	Alpine associations (ÖAV, DAV)	Municipality (Gemeinde)	Tourism associations	NP Kalkalpen	LEADER
Small forest owners	Biomass heating plant		Forest consultants	Tourism associations	EU	Day tourists	Advisory panel (Kuratorium NP Kalkalpen)	LUKA (Arbeitskreis Luchs)
Large forest owners	Paper factory			Naturfreunde	Federal state	Nature-loving tourists	Federal Forests Austria (ÖBF)	Forestry schools (Forstfachschulen)
Large land owners	Sawmill			Naturschutzbund	Forest authority	Tourists	State forests (Landesforste)	
Federal Forests Austria (ÖBF)	Admonter Holzindustrie AG			NGOs	Landesrat für Naturschutz	Civil societies	Steiermärkische Landesforste	
Wilderness Area Dürrenstein-Lassingtal	Timber construction (Holzbau)			WWF		Local population	Wildnisgebiet Dürrenstein	
State forests (Landesforste)				Land owner representatives			Natur- und Geopark Eisenwurzen	
City of Vienna				Forest owners association			Nature reserves	

Stift Admont (monastery)	Forestry representatives	City of Vienna
Aristocratic families	Farmner's union (Bauernbund)	Naturfreunde
Diocese Salzburg		Naturschutzbund
National parks		NGOs
NP Gesäuse		WWF
NP Kalkalpen		
Advisory panel (Kuratorium NP Kalkalpen)		
National park management		
Nature reserves		
Natur- und Geopark Eisenwurzen		
Forest ranger		
Hunters		
Operations manager (agriculture, forestry)		

Annex F: Confirmation of online survey data loss

Universität für Bodenkultur Wien
University of Natural Resources and Life Sciences, Vienna

BOKU-IT
Direktor: Dr. Andreas Schildberger
Peter-Jordan-Straße 82
A-1190 Wien

Vienna, 19th January

To whom it may concern

We hereby confirm that due to a software error, the following surveys experienced a permanent loss of the private part of the encryption key pair, and thus the data itself, during a system update:

- Land use and climate change in the Eisenwurzen (ID 241465)
- Cambio climático y uso del suelo en Doñana (ID 682846)
- Land use and climate change in the Eisenwurzen (ID 574515)

Bastian Bertsch-Hörmann as the creator of the survey is not at fault and had no possibility to avoid this incident.

best regards

Andreas Schildberger

SIGNATURINFORMATIONEN		
	Unterzeichner	DI Dr. Andreas Schildberger
	Datum/Zeit-UTC	2023-01-19T17:23:21+01:00
	Prüfinformation	Informationen zur Prüfung der elektronischen Signatur finden Sie unter: https://www.signaturpruefung.gv.at
Hinweis	Dieses mit einer qualifizierten elektronischen Signatur versehene Dokument hat gemäß Art. 25 Abs. 2 der Verordnung (EU) Nr. 910/2014 vom 23. Juli 2014 ("eIDAS-VO") die gleiche Rechtswirkung wie ein handschriftlich unterschriebenes Dokument.	