D3.2. Methodological framework “Living Labs”

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Revision and history chart

Version	Date	Main author	Summary of changes
0.1	11.11.2024	Mihaela Sima et al.	Development of the first draft of the report
0.2	26.11.2024	Mihaela Sima	Completion of the content for the first draft based on comments from coordinator and all partners
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ABSTRACT

Living Labs (LLs) have emerged as an effective participatory methodology for user-driven innovation and co-creation, particularly in addressing complex, real-world challenges. This deliverable D3.2 explores how Living Lab methodologies can support the Europe-LAND project by fostering participatory approaches and co-developing tailored solutions for sustainable land use and management in the context of climate change and biodiversity challenges. Drawing on a systematic literature review and real-world experiments, the report examines various frameworks and lessons learned in previous initiatives and proposes a dedicated Living Lab Framework to facilitate stakeholder interactions at national, regional and local levels. This pan-European Living Lab Framework with an associated Co-Creation Roadmap serves to identify in a systematic manner the complex challenges, gaps, and opportunities in sustainable land management at multiple spatial levels. First experiences regarding the practical utilization of the framework is illustrated in the report by providing an overview of land sustainability challenges within the eight case studies proposed in the project that will, as the project progresses, be discussed by means of stakeholder interaction on local level, and it also summarises the experience gathered during national level "Mirror Workshops" in Europe-LAND's twelve EU partners' countries. These particular workshops resemble a key first element of the roadmap and facilitated participatory engagement to both jointly analyze with the stakeholders the current and future land management challenges as well as to co-develop the characteristics of potential Land Futures in pursuit of the ultimate objective of living labs, i.e. user-driven innovation and co-creation.

KEYWORDS

Living Lab, Framework, participatory approach, land use, land management, climate change, biodiversity, literature review, stakeholders' mapping, Mirror Workshop

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List of Abbreviations and Acronyms

LL/LLs	Living Lab/Living Labs
WP	Work Package
ENoLL	European Network of Living Labs
LTSER	Long-Term Socio-Ecological Research Programme

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Annex 1. Countries’ Reports of the Mirror Workshops

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Executive Summary

Living labs, as a methodology to enhance user-centric innovation and to co-create solutions to real-world problems, have gained interest in the last years, especially in Europe, with the establishment in 2005 of the European Network of Living Labs. More recently, European mission "A Soil Deal for Europe", launched in 2021 aims to establish 100 living labs and lighthouses for the transition to healthy soils by 2030. In this respect, the purpose is to accelerate the adoption of sustainable land management practices and engage farmers and other agricultural stakeholders in creating tailored solutions to land sustainability challenges at regional and local level.

As such, the living lab approaches and methodologies have been proved as a good option across various fields for co-creating solutions to complex real-world situations. This is the main objective of this deliverable report (D3.2. Methodological framework "Living Labs"), to explore how living lab methodologies can be a useful tool to respond to the Europe-LAND aims and they can be used to explore and better understand the awareness of climate change and biodiversity challenges in relation to land management.

As stated in the Description of action of the Europe-LAND project, task T3.2 ("A Living Lab Framework for understanding the awareness of climate change and biodiversity challenges") is focused on using a living lab approach to interact with the stakeholders in order to determine their perceptions on the use of land resources under current and future climatic conditions, their interest to adopt different management practices to address climate change and biodiversity challenges as well as their needs and requirements in terms of tailored instruments, tools and future scenarios. The target group of the project is represented by the land users, managers, local authorities and regulatory agencies with a national-driven orientation, which will be identified by each partner through a detailed search of various professional networks. In this respect, a national, regional and local database of the stakeholders will be prepared for each country involved in the project, and a well-defined methodological framework to approach different categories of the stakeholders will be developed in this task. The results of the living lab approach are aimed to be used by the partners to adapt their research methods and simulation tools to properly address the real-life challenges experienced by the involved actors in terms of adopting sustainable land use management in the context of climate change. Moreover, the multiple laboratory contexts provided by the pilot cases developed in the project will be used to test and validate the EUROPE-LAND Toolbox developed in WP6. The methodological framework and guidelines developed in T3.2 will be tested during the interactions planned in T3.3 and T3.4.

The main outcome of this task is to provide a pan-European methodological framework that explores the awareness of key actors at various scales about climate change and biodiversity challenges, and identify the problems, gaps, expectations, barriers to change in land-use management and/or to adopt conservation practices, and local characteristics of land uses, environmental attitude, the willingness to adopt different alternatives to overcome climate change and biodiversity challenges. In addition to presenting the Living Lab methodological framework for the project, this report also incorporates findings from the first two stages of its application. Stage 1, focused on co-design, explores the 8th Europe-LAND case studies by examining past and present land management challenges and conducting stakeholder mapping. Stage 2, centered on co-creation and co-development, analyzes the results of participatory workshops that engaged stakeholders in identifying current and future land sustainability challenges and developing narratives for future scenarios (Land Futures).

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The results of the task will provide the basis for the in-depth interviews and focus groups performed in T3.2 with the representatives of key actors, to guide the living lab approach with the local stakeholders in T3.5 as well as to orient the activities within WP4, 5 and 6.

Along these lines and considering the specific requirements of various tasks involved in the project that benefit from multi-stakeholder involvement, the Europe-LAND Living Lab Framework is seen as a practical, operational and participatory framework to be used by the partners to fulfill the main project objectives. As a consequence, it was designed on a multiple level, to target the national and regional/local levels, in line with the construction of the project and it proposes a sequence of activities planned along national to local-oriented Roadmaps to cover the timespan of the project.

The current report is structured in 4 chapters:

- Chapter 1 aims to introduce the Living Lab concept and to provide an overview of its various uses so far, being based on an extensive and systematic literature review. The purpose of the analysis was to provide an overview of Living Lab features, to examine existing Living Labs frameworks in terms of theoretical and conceptual structures, and evaluate the participatory methods used to engage stakeholders. Additionally, it explored the challenges and best practices in designing and implementing a Living Lab approach, that could be useful for further initiatives, looking also at various methods for exploring the climate change awareness-knowledge gap, the role of foresight methods in Living Labs and ethical aspects in desigining a living lab approach.
- Chapter 2 introduces the methodological flow followed in Europe-LAND to design the Living-Lab Framework and associated Roadmaps at the national and regional/local levels. It gives an overview of the activities performed so far, starting with stakeholders' identification and mapping, as well as the characterization of the Europe-LAND case studies in terms of past and current land management challenges.
- Chapter 3 is focused on the results obtained following the organization in each partner's county (12 countries) of a series of participatory workshops, entitled 'Mirror Workshops', that aimed to use a similar format and concept to provide a preliminary analysis of current and future land sustainability challenges.
- Chapter 4, the conclusions, summarize the lessons learned during the co-creation workshop exercise, the directions of further research and how living lab tools may further support the process of multi-stakeholder engagement in Europe-LAND.

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1. Living Labs – Conceptual Framework

1.1. Introduction

Living Labs (LLs hereafter) build on a tradition of user-centered, participatory research, serving as models of social innovation by involving users, consumers, and citizens to generate ideas, knowledge, and experiences (Ruijsink and Smith, 2016; Eriksson et al., 2005). Despite their history, LLs are a relatively new method, using multidisciplinary approaches to test ideas in real-life settings (Snep et al., 2023). They transcend disciplinary boundaries (Kofler, 2023) and promote transdisciplinary collaboration (Laborgne et al., 2021). LLs bring together diverse actors, resources, and activities to co-create, prototype, and test innovations in real-world contexts (Leminen, 2013; Dell'Era and Landoni, 2014; Compagnucci et al., 2021).

LLs originated in the late 1990s at MIT to drive innovation in ICT (Eriksson et al., 2005; Zavratnik et al., 2019). By 2006, EU policies adopted LLs to address innovation gaps and societal challenges, establishing the European Network of Living Labs (ENoLL) (Dutilleul et al., 2010). ENoLL defines LLs as "user-centered open innovation ecosystems" integrating research and innovation in real-life settings. LLs are characterized by five key components: 1) active user involvement, 2) real-life settings, 3) multi-stakeholder participation, 4) a multi-method approach, and 5) co-creation[1].

LLs foster practitioner and researcher **collaboration** in real-life settings, acting as networks for innovation among Quadruple Helix Model actors: citizens, government, industry, and academia (Higgins and Klein, 2011; Metta et al., 2022). While these models guide innovation, gaps often exist between theory and practice (Nguyen et al., 2022). To address societal challenges, Carayannis and Campbell (2010) introduced the Penta Helix, adding the natural environment to emphasize socio-ecological transitions in innovation and knowledge. This approach provides a holistic framework for innovation, emphasizing natural environments' role (Merino-Barbancho et al., 2023). Carayannis and Campbell (2021) highlight how the Quadruple and Quintuple Helix systems support the transition to Society 5.0, stressing collaboration among diverse stakeholders to tackle modern challenges.

The Quadruple and Quintuple Helix models address the evolving knowledge society, with the Quintuple Helix receiving less empirical focus (Cai and Lattu, 2022). LLs integrate Quadruple Helix actors to co-create transdisciplinary solutions, fostering sustainable partnerships for complex societal challenges (Kalinauskaite et al., 2021). Now part of "real-world laboratories" (Schäpke et al., 2018), LLs emphasize two key principles: real-life contexts and co-creation (Soini et al., 2023).

The **real-life context** is crucial in co-creation, allowing collaboration with stakeholders to identify challenges, design solutions, and implement them (Hossain et al., 2019; Soini et al., 2023). It is vital for both the innovation process and scaling results by identifying commonalities in physical and socio-economic environments across different LLs (Soini et al., 2023). While there is consensus that LLs are embedded in real-life contexts, the literature reveals diverse interpretations of what this context means and its role in the co-creation process (Hossain et al., 2019).

Soini et al. (2023) identify three key aspects of a real-life context: (1) a **physical setting** (e.g., city, rural area, region) with unique socio-economic, cultural, and political features; (2) **innovation activities**, including testing and validating ideas and prototypes using local knowledge; and (3) the concepts of

[1] https://enoll.org/

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"place" and **"space",** which explore participants' relationships, connections to the environment, and public acceptance of nature-based solutions (NBS).

LLs transition from a participatory approach to a user-centred approach engage users throughout the entire design process, from problem exploration to testing (Akasaka et al., 2022). Unlike traditional methods that involve users in specific phases like idea generation and prototyping (Brandt, 2006), LLs foster long-term, complex user participation (Akasaka et al., 2022). This approach views users as key sources of innovation, actively consulting them to understand their needs (Dell'Era and Landoni, 2014).

The extensive literature on participatory approaches and Living Labs spans multiple disciplines, highlighting diverse characteristics. A systematic review by Hossain et al. (2019) identified eight key characteristics of LLs: real-life environments, stakeholders, activities, business models, methods, tools, challenges, outcomes, and sustainability. Thus, the literature on Living Labs is defined by key terms such as co-creation, co-innovation, prototyping, user-driven, multi-stakeholder and multi-method approaches, collaborative platforms, and real-life settings. These terms form the core of various definitions of the Living Labs approach.

Sanders and Stappers (2008) place LLs within the human-centered innovation approach. Almirall et al. (2012) expand this by considering two dimensions: user participation in co-creation and the settings for this participation, whether lab-like or real-life environments. User-centered design fosters innovation by involving users early to understand their needs, leading to tailored products and services (Arnould et al., 2022). The LLs concept has evolved, emphasizing users as active co-innovators (Higgins and Klein, 2011; Greve et al., 2020).

Leminen et al. (2012) identified four types of LLs—utilizer-driven, enabler-driven, provider-driven, and user-driven (Fig. 1) —that facilitate co-creation in settings replicating real situations through collaboration between users, organizations, and research institutions.

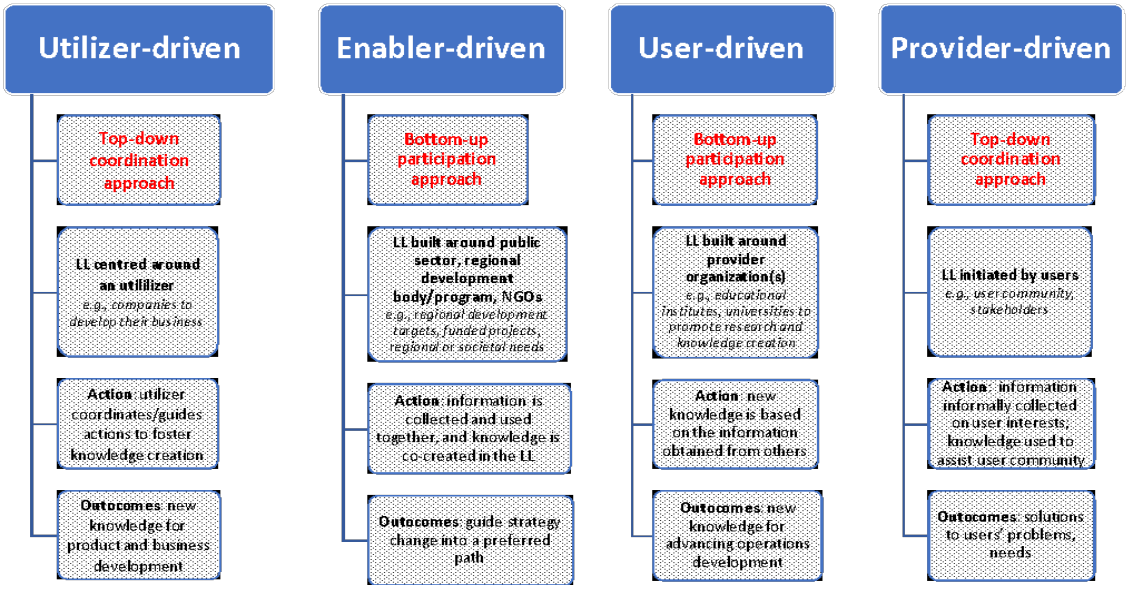

Fig. 1 LLs models according to the type of actors (adapted after Leminen et al., 2012; Compagnucci et al., 2021)

Stakeholder participation in LLs typically involves multi-level engagement through collaborative learning, prototyping, evaluation, policy assessments, and community-driven decision-making. Key participation modes include:

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- *Co-creation and knowledge sharing* through workshops for co-design and real-world testing (e.g., Dell'Era et al., 2019; Fèche et al., 2021).
- *Shared decision-making* to align actions with policy goals and sustainability (e.g., Dell'Era et al., 2019; Ciaccia et al., 2021).
- *Locally-driven solutions* developed through real-life experimentation, especially in rural areas (e.g., Toffolini et al., 2023).
- *Empowered participation* giving citizens influence in decision-making (e.g., Soini et al., 2023).
- *Feedback and evaluation* via continuous feedback loops to refine outcomes (e.g., Ciaccia et al., 2021; Mitić-Radulović and Lalović, 2021).
- *Testing and implementation* through real-world trials to validate and adjust solutions (e.g., Mitić-Radulović and Lalović, 2021).

Involving stakeholders and users early in co-creation often turns them into active contributors, shaping outcomes with their knowledge and experience (Menny et al., 2018; Akasaka et al., 2022). Depending on engagement goals and stakeholders involved, a participation framework can follow either the "ladder of participation" (Arnstein, 1969) or the "wheel of participation" (Davidson, 1998). The "ladder" provides a hierarchical model, emphasizing increasing stakeholder influence, and helps policymakers determine engagement levels (Hurlbert & Gupta, 2015, 2024). In contrast, the "wheel" offers flexibility, recognizing that varying engagement levels may be needed at different stages or for different objectives (Menny et al., 2018).

According to Westerlund et al. (2018a), a living lab is a sociotechnical platform that combines shared resources, collaboration, and real-world contexts to form an innovation ecosystem. It involves stakeholders working together using open standards, diverse methods, and governance to create, validate, and deliver new knowledge, solutions, professional development, and social impact.

Følstad (2008) conducted an initial analysis of LLs by reviewing 32 papers to explore their theoretical foundations, processes, methods, and perspectives. Later, Dutilleul et al. (2010) identified three key aspects of living labs: settings for *in vivo experimentation*, user-involved innovation and product development, and innovation systems.

Leminen et al. (2012) explored the concept of LLs by analyzing 26 LL entities across Finland, South Africa, Spain, and Sweden, offering various perspectives on these innovation environments. Leminen (2013) further proposes a matrix to classify LL networks based on coordination (top-down vs. bottom-up) and participation (exhalation-dominated vs. inhalation-dominated), identifying four types of LL networks (Fig. 2). Despite this, Schuurman et al. (2015) found a gap in empirical, quantitative, and comparative research on LLs, based on their analysis of the 45 most-cited papers on the topic.

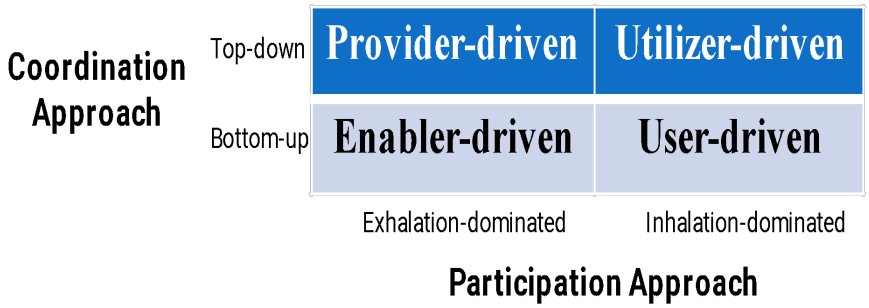

Fig. 2 A matrix of innovation mechanisms in LL networks (Leminen, 2013)

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Leminen and Westerlund (2016) identified eight key research streams in the LLs literature. Leminen et al. (2017) reviewed 195 articles to expand understanding of the LL movement. McLoughlin et al. (2018) conducted a bibliometric analysis of 169 articles to assess the scholarly impact and structure of LLs in innovation. Westerlund et al. (2018b) applied topic modeling to 86 publications, categorizing LL research into seven main topics: Design, Ecosystem, City, University, Innovation, User, and Living Lab. Hossain et al. (2019) reviewed 114 articles to analyze LL paradigms, stakeholder roles, contexts, challenges, outcomes, and sustainability. Greve et al. (2020) conducted a systematic review of 411 core journal articles on LLs, highlighting the field's diverse and fragmented nature. However, they identified clusters of scholars and publications through keyword co-occurrence, revealing different theoretical foundations. Akasaka et al. (2022) developed a new framework for configuring user participation in LLs, known as the "Participation Blueprint" (PBP). This framework includes five categories: phase, participants, format, contact, and motivation management.

Recent LL approaches have fostered innovative solutions through participatory tools and multi-stakeholder engagement in EU-funded initiatives, such as Horizon 2020 projects like SmartCulTour, DESIRA, and CIRC4Life. Additionally, the EU's "A Soil Deal for Europe" mission in the Horizon Europe 2021–2027 program highlights a communication gap between governments, stakeholders, and citizens (Bouma, 2022).

LLs have been developed worldwide across various domains, including urban development, healthcare, education, energy, ICT, and culture, organized around different conceptual frameworks. In the Europe-LAND project, particular focus was given to LLs addressing agriculture, sustainability, biodiversity, climate change, agroecology, and rural development. The LL framework is increasingly applied in agriculture, emphasizing partnerships and roles in innovation. However, few studies have explored how the framework has been implemented in relation to the experimental practices it is based on (Toffolini et al., 2023). The agricultural sector, including agroecology and rural development, has recently embraced LL approaches, particularly following their central role in the European H2020 programme. Several projects have used LLs as a primary methodology or focus, including Robust (Kobzeva and Knickel, 2018; Oedl-Wies et al., 2020; Bauchinger et al., 2021), LIVERUR (Zavratnik et al., 2019), and Agrilink (Potters et al., 2022).

Sustainability-oriented LLs have been applied in various food systems. For example, Wolfert et al. (2010) created a LL in the Dutch agri-food sector to promote sustainable farm management through optimized information supply. Pereira et al. (2022) conducted a transformation lab in South Africa's Western Cape to enhance the sustainability and inclusivity of the local food system. In Norway's Vestfold region, Hvitsand et al. (2022) implemented a LL to support agri-food systems with organic vegetables. Additionally, Gamache et al. (2020) performed a bibliometric analysis to assess if agri-food LLs support local transition pathways. LLs can foster collaboration in rural communities, drive business development, and positively impact rural development by leveraging local characteristics (Schaffers et al., 2009). They serve as tools for social innovation in these areas (Tirziu and Vrabie, 2017). Additionally, transdisciplinary SDG Labs can help create biodiversity-based solutions to promote sustainable food systems (Jarzebski et al., 2023).

The "A Soil Deal for Europe"[2] mission, launched by the European Commission in 2021, aims to develop sustainable land solutions by establishing 100 living labs and lighthouses to promote healthy soils by 2030. The initiative focuses on engaging farmers and stakeholders to adopt sustainable agricultural

[2] https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe/soil-health-and-food_en

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practices through tailored solutions for local challenges. Organic lighthouses demonstrate organic practices for educational purposes and collaborate with research institutions. Networks from EU-funded projects, like ALL-Ready, Agroecology-TRANSECT, and DESIRA, support the selection of inspiring case studies (Mambrini-Doudet et al., 2021). The Bio Danubius project, a living lab in Romania's Danube Delta, exemplifies agroecological innovation through capacity-building and co-creation processes (Lianu et al., 2023, 2024).

1.2. General features of Living Labs frameworks

The scope of LLs is to search for specific solutions to specific problems. A general methodological framework for approaching LLs will be provided, integrating its key elements (i.e., user-centred, co-design, co-creation, co-development, multi-stakeholder engagement, innovation). This framework will serve as the base for the Europe-LAND project, establishing a cohesive methodology that facilitates collaboration among diverse stakeholders and drives innovation. While ensuring consistency across the project, the framework will be designed to be adaptable and flexible, allowing for the integration of regional differences (place-specific) and specific project requirements. It will support a shared understanding for tackling the complex challenges of each case study and encourage the exchange of knowledge to identify sustainable solutions through the design of a common LL framework. By remaining flexible, the framework will enable the Europe-LAND project to create a dynamic network of LLs that can evolve in response to the changing environments posed by the case studies. However, since each case study is confined to a certain region with individual characteristics that dictate the uniqueness of the problems addressed, it is important that each LL adapts this methodological framework to be tailored so as to respond to the specific local needs.

Understanding and implementing a Living Lab concept can be challenging requiring careful consideration of key questions. Drawing on the work of Hossain et al. (2019), Akasaka et al. (2022), and Mbatha and Musango (2022), among others, these include: *i) What are the key characteristics of LLs? (ii) What is the primary goal of the LLs? (iii) Who are the key stakeholders involved? (iv) What services will the LLs facilitate? (v)Who will be responsible for leading the LL? (vi) What infrastructure, methods and tools for interaction will be needed? (vii) What innovation outcomes are expected, and who will be the main beneficiaries? (viii) How will the success of the LL be evaluated? (ix) What are*

Recent efforts to conceptualize Living Labs (LLs) have garnered attention through literature reviews and insights from European projects. Key frameworks include:

- Kalinauskaite et al. (2021) proposed four stages for transdisciplinary collaboration: stakeholder mapping, scope definition, strategic impact mapping, and roadmap definition.
- The co-creation paradigm is central to LL frameworks, especially in rural areas (Zavratnik et al., 2019).
- Akasaka et al. (2022) introduced the "Participation Blueprint" (PBP), a framework with five categories: phase, participants, format, contact, and motivation management.
- Lupp et al. (2020) outlined three phases: setup (design, planning, co-creation), working (co-design, scenario creation, user participation), and outcome (evaluation, implementation, monitoring).
- Metta et al. (2022) applied a socio-cyber-physical framework across 21 agricultural LLs, structured into focal question setting, participatory mapping, and impact assessment.
- Almirall et al. (2012) outlined four stages: contextualization, concretization, implementation, and feedback.
- Bouwma et al. (2022) developed an assessment framework focusing on LLs' dynamic role and capabilities in addressing transition challenges (Tabble 1).

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These frameworks help guide the development and evaluation of LLs across various domains.

Table 1 Qualities related to the collective capabilities of the Living Lab

Performance Areas	Collective Capabilities	Related Abilities
Motivation of the LL	Responsive	Driven by urgency to tackle transition challenges
Design and setup of the LL	Relevant	Addressing both transition challenges and stakeholders' needs
	Resourceful	Securing necessary resources for lab activities
LL interactions	Connected	Collaborating with external actors to avoid isolation
	Together (Collaborative)	Fostering shared ownership among partners.
LL actions	Practical and propositional	Focusing on actionable outcomes to maintain engagement
	Responsible	Balancing practicality with quality and inclusivity
Positioning and reputation of the LL	Known and acknowledged	Communicating effectively to relevant audiences. Managing reputation and demonstrating effectiveness
LL products and services	Generative	Producing tangible products and services
	Motivational	Engaging participants by connecting to their interests
Outcomes and impact of the LL	Effective and adaptive	Assessing social, economic, and environmental impacts. Adjusting actions based on monitoring and evaluation

Processed and adapted after Bouwma et al. (2022)

1.3. Lessons learned from the literature review of Living Lab-related approaches

A systematic literature review has been done to evaluate scientific production related to the living lab approach that could help explore the stakeholders' awareness regarding land sustainability challenges considering climate change and biodiversity conservation, which is the main purpose of the Europe-LAND LL Framework.

The analysis served several purposes: it aimed to identify current research themes, examine existing Living Labs (LL) frameworks in terms of theoretical and conceptual structures, and evaluate the participatory methods used to engage stakeholders. Additionally, it explored the roles of stakeholders, challenges, and best practices in designing and implementing the Living Lab approach that could inform future initiatives. Evaluation criteria were also reviewed to provide a comprehensive overview for new endeavors.

Since a detailed systematic literature review will be covered in an upcoming publication, this report highlights the key lessons learned regarding living lab approaches (Fig. 3). The literature provides a series of recommendations on various aspects of configuring and implementing a Living Lab, offering practical insights for new initiatives of this kind. These recommendations are presented either positively—as good practices, advice, or enablers—or as challenges, obstacles, or barriers, often accompanied by suggested solutions. Through an in-depth analysis of the literature, we compiled a comprehensive inventory of these recommendations, which were then categorized according to key

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structural components of a Living Lab: aspects to consider from the project planning stage, general organization, management, and governance of the Living Lab, strategies for stakeholder engagement and motivation, communication and collaboration methods, conditions, methods and techniques for the co-creation stage, approaches for evaluation and follow-up, and considerations for the post-implementation phase.

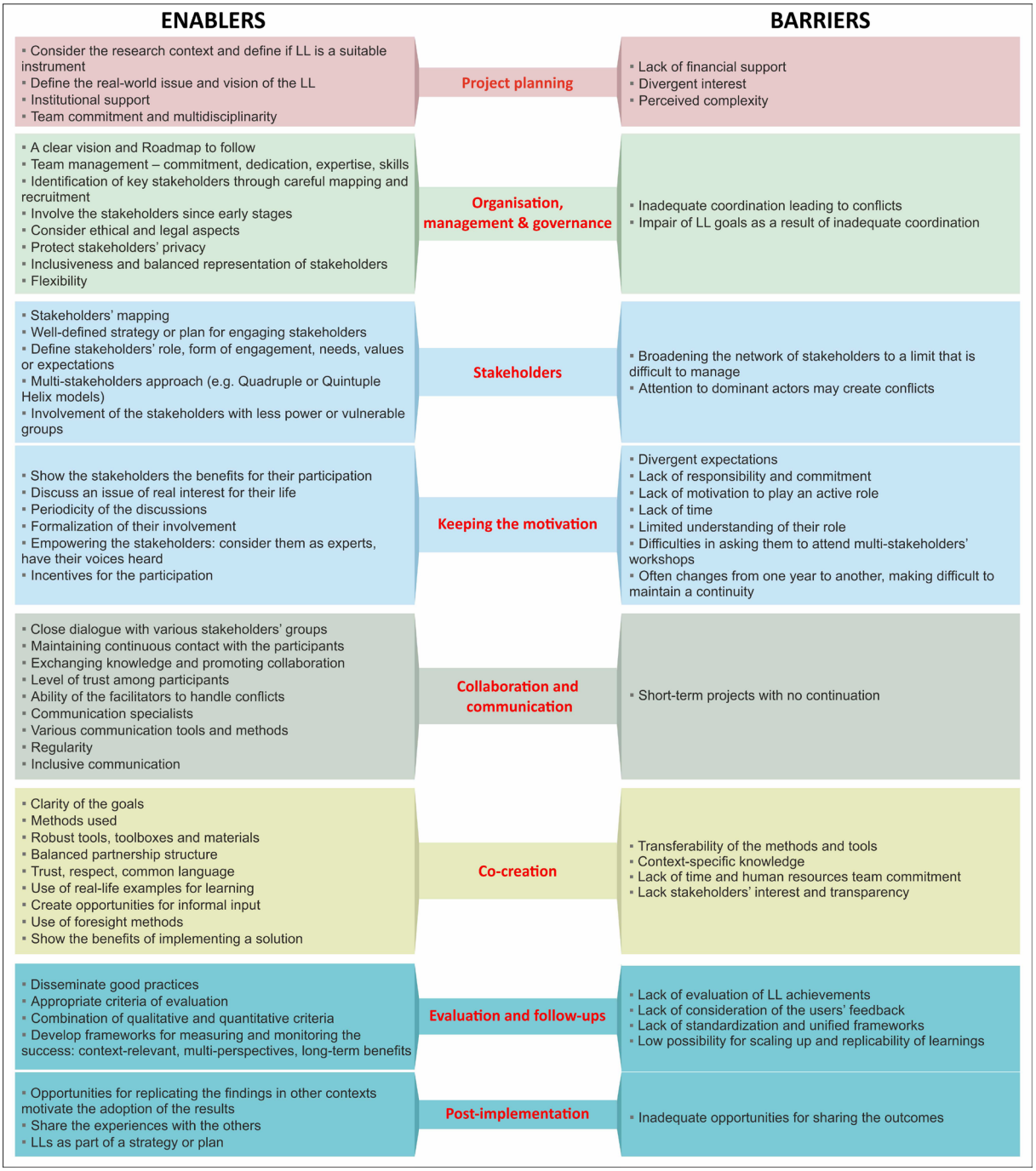

Fig. 3 Lessons learned (expressed as enablers or barriers) in the analysed publications

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1.4. The role of LL approach in addressing the climate knowledge–action gaps

The impact of climate change on agriculture and biodiversity has become one of the greatest challenges of our time (UN Report, 2023); thus it is essential to consider the role of understanding the gap between knowledge and action in climate change adaptation. While our understanding of climate change has accelerated in recent decades, both in scientific knowledge and in how population perceive these phenomena, actions related to climate change adaptation have not kept pace and are often considered insufficient (Knutti, 2019). The knowledge-action gap in science and practice occurs when research outputs fail to result in actions (land-management actions) (Roche et al., 2021). Scientific studies over the past 20 years have highlighted that understanding climate change is distinct from knowing how to address the problem effectively (Naustdalslid, 2011). Over the last decade, international scientific literature on climate change has included numerous studies focusing on the challenges and barriers to bridging the knowledge-action gap (West et al., 2019). The literature review has provided a comprehensive understanding of the intention/knowledge-action gap - what we aim to achieve versus our actual actions - concluding that scientific knowledge alone is not enough to trigger behaviour change or effective action (Malik, Ford, 2024; Wakatsuki et al., 2023; Mooney et al., 2022; Knutti, 2019).

Given the disproportion between people's awareness of climate change and their limited engagement in action, we explore barriers that may underlie the disconnection between scientific knowledge and concrete action (Dupont et al., 2024). There are several potential reasons behind the gap between individual knowledge of climate change and their actions. Based on literature, among the diverse and complex reasons for this gap, these barriers have been identified and grouped into seven main categories, as shown in Fig. 4. One of the most complex categories involves the individual factors: socio-economic variables such as socio-economic inequalities and educational level. Educational level, in particular, significantly and positively influences the likelihood of adopting adaptation actions/strategies, since educated people are expected to be more inclined to embrace new technologies due to their awareness of the available climate change adaptation measures (Bagagnan et al. 2019; Belay et al., 2017). Other very important factors include demographics (Ricart et al., 2023; Alotaibi et al., 2020); personal experience (Thangrak et al., 2020), motivation (Ricart et al., 2023); perceived self-efficacy (Madaki et al., 2023; van Valkengoed, Steg, 2019); risk perception (van Valkengoed et al., 2023). Additionally, subjective factors (e.g. cognitive, emotional, attitude, intentions, general beliefs, knowledge) play significant roles (Malik, Ford, 2024; Grigorieva et al., 2023; Ricart et al., 2023; IPCC, 2022; Loboguerrero et al., 2019; Knutti, 2019; Hoegh-Guldberg et al., 2018). According to Paudel et al. (2022), Sujakhu et al. (2020), Zhang et al. (2020) or Bagagnan et al. (2019), some adaptation options are resource-intensive, making them inaccessible for people with limited capital or without access to financial support. Other authors (van Valkengoed, Steg, 2019; Thomas et al., 2021; Knutti, 2019) consider that local context (local funding/financial factors; cultural factors; socioeconomic context; demographics) and the availability of facilities and services (e.g. infrastructure, technology) creates additional knowledge-action gaps that influence the decision to combine multiple strategies to cope with climate change (Malik, Ford, 2024; Ponce et al., 2021; Lynch et al., 2021; Mechler et al., 2020). The components related to policy support such as governance constraints, lack of descriptive norms, political factors (Thomas et al., 2021) are also important. Equally important are those related to information sources (Madaki et al., 2023), lack of insurance (Loboguerrero et al., 2019) or insufficient support from regional and international level (Loboguerrero et al., 2019). The analysis focused on extracting relevant data and case studies related to good practices from selected scientific

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papers and reports to ensure a comprehensive understanding of the current situation. We explored the implications of these findings for designing future action plans aimed at bridging the knowledge-action gap. Actions to address these gaps include: training programs, support for ongoing learning, living labs (Gardezi et al., 2024; Grigorieva et al., 2023; Vyas et al., 2022), focus groups (Palermo, Hernandez, 2020), workshops (Frazier et al., 2010), seminars, interactive plenary sessions, interviews (such as in-depth and face-to-face interviews to gain insights into the specific needs, challenges, aspirations, local perspectives, and contextual influences - Gardezi et al., 2024). Additionally, surveys, dedicated research activities, participatory action research (Barberi et al., 2023; Bouwma et al., 2022) are equally important. Improving and strengthening human capital, through education and outreach, enhances decision-making capacity at all levels, thereby increasing the collective ability to close the knowledge-action gap (Akinnagbe, Irohibe, 2014). Collaborative design workshops play a critical role in developing diverse future scenarios and create a space for creative thinking, open dialogue, and thoughtful consideration for how AI might practically address these gaps. For local planners to develop truly comprehensive land-use plans, they need access to information that helps them determine appropriate action plans given the complexity and uncertainty of climate-change predictions. These action plans enable local participants to expand their understanding of the topic.

The Living Lab approach plays a significant role in addressing the knowledge-action gap by transforming awareness into concrete, sustainable actions. Living Labs are real-life environments where stakeholders from different sectors collaborate to co-design, co-create, and co-develop innovative solutions to complex challenges (Compagnucci et al., 2021). Involving stakeholders in long-term comprehensive planning that reflects the diverse expertise, political agendas, and social interest of a community is critical (Beaudoin et al., 2022; Compagnucci et al., 2021; Delina, 2020; Westerlung, 2019; Schaefer, Scheele, 2014). Numerous situation-specific factors can only be understood and transformed into useful social knowledge through experiments conducted in real-life contexts (Schaefer, Scheele, 2014). Some strategies for closing the knowledge-action gap involve integrating various types of learning, scientific knowledge, socio-economic strategies, digital innovation, AI tools, policy instruments, technological innovation, climate-smart pathways, policy initiatives, abilities, beliefs (Barberi et al., 2023; Bouwma et al., 2022; Vyas et al., 2022).

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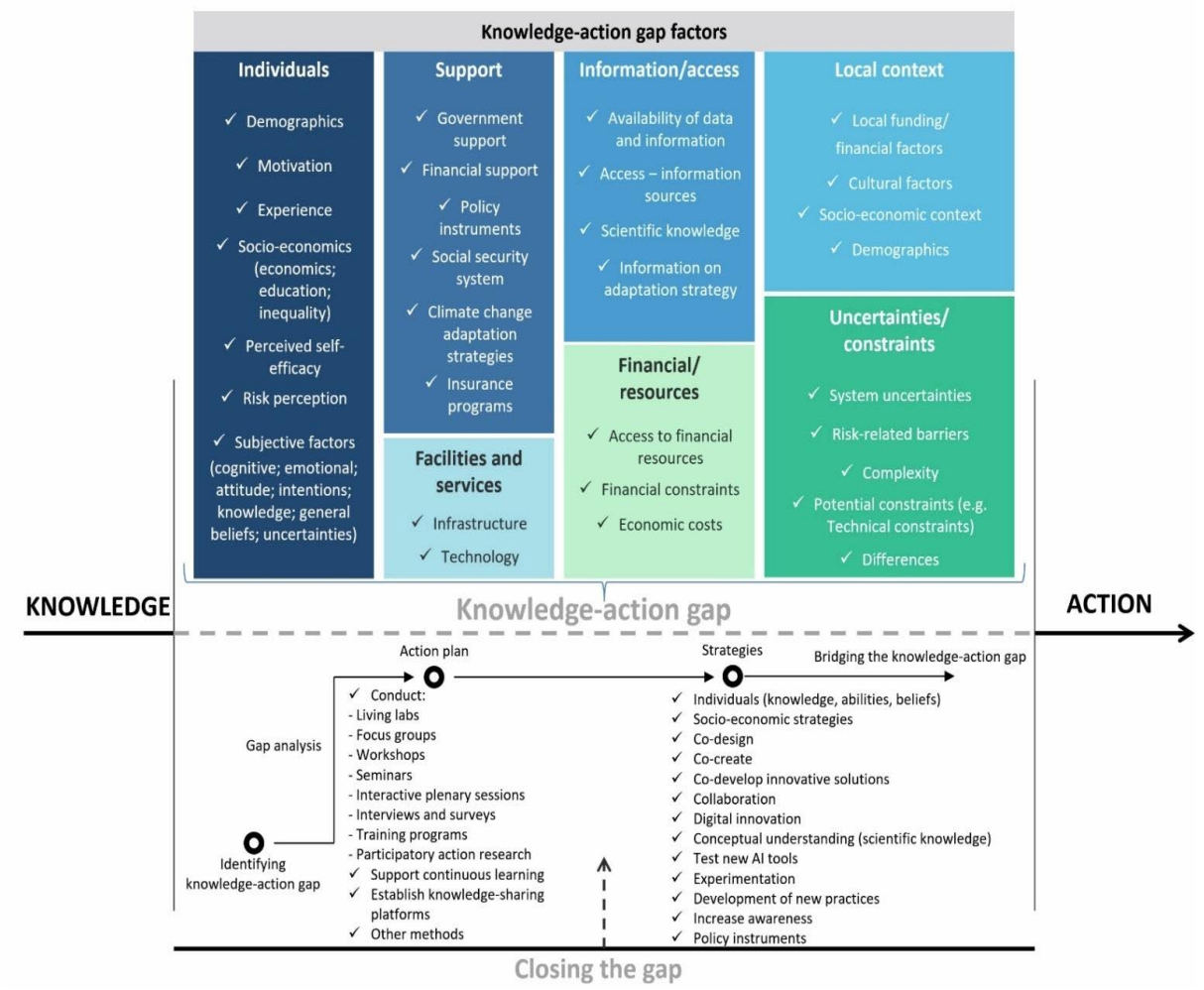

Fig. 4 Factors, actions and strategies to bridge the climate knowledge-action gap (Source: own development based on the literature review)

1.5. The role of foresight methods in the LL approach

Foresight is the process of anticipating, expecting and exploring possible futures and future results and it can be used as a way to facilitate the present-day decisions and strategies in order for them to be more efficient and suitable for the future. Foresight methods are often used to help decision makers to anticipate long-term developments, identify emerging trends, and address potential risks and uncertainties.

In general, several different foresight methods can be found in the scientific literature and with a wide range of applications and different characteristics. For example, there are qualitative methods, quantitative methods and semi-quantitative. Regardless of the category they belong to, some foresight methods are used more widely than others, and the expert panels and the scenarios are two of them. Other methods commonly used, however to a bit lesser extent, are extrapolation/megatrends, the Delphi method and the questionnaires/surveys (Popper R., 2008).

Among the available methods for exploring possible futures, scenario planning is one that is widely used, and especially within a Living Lab setting, this method can be particularly useful and practical. Scenarios are narratives or stories that explore different potential futures and can take into account

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various factors, like social, political, economic and technological. Within the framework of a Living Lab, scenarios can be used to:

1) guide the development of user-centric solutions that are flexible and adaptable to different future conditions,

2) identify critical factors and uncertainties that could affect the success of innovations,

3) enhance the relevance of solutions by testing them against diverse possible futures, and more.

The first step in order for one or more scenarios to be generated is usually to have the main uncertainties and the most important factors regarding a certain situation, and possible future developments regarding it, identified (Chermack, 2011). Technological advancements, societal shifts, regulatory changes and environmental challenges can all be such uncertainties. Once the aforementioned factors have been identified, different scenarios can be created that can show how these factors can lead to different futures.

Within the framework of Living Labs, the scenario planning process is usually participatory and people from several different fields and backgrounds can, as well as should, be part of it. For example, stakeholders ranging from researchers to industry representatives and from policymakers to citizens can be part of the process. The aforementioned fact can contribute to the scenarios created being grounded in real-world concerns and perspectives.

The use of foresight methods (and specifically scenario planning) within the framework of Living Labs can be proven to be a useful tool. This can be especially true in situations and issues that affect several different stakeholders. Such an example would be the Living Labs that focus on urban and sustainability issues.

One significant such example would be the use of scenario planning in Living Labs on the topic of sustainability transition. Societal, environmental, and technological innovations can be at the heart of these Labs and scenario planning can provide the stakeholders with a way to explore several different futures. Moreover, it can provide a way for potential risks to be identified, as well as a pathway for desirable changes to be proposed. In this context, the foresight method used can assist in the achievement of sustainability goals, while also facilitating technological advancements and/or social innovations (Baškarada et al, 2016).

Moreover, the use of foresight methods within the Living Lab framework can help in the decision-making process and it can also promote organizational learning. By advancing the knowledge and understanding regarding potential future risks it can facilitate the individuals and organizations that are taking part in the Lab, and even government agencies if they are participating, to make better and more informed decisions on several different topics, with possible future environmental problems being some of them. This can be proven to be a particularly important fact for organizations, as well as government agencies, that have set the goal to transition towards more sustainable practices.

Additionally, a significant benefit of the use of different scenarios can be the following: shared visions of the future can be created among some or all the stakeholders taking part in the Living Lab. This, in turn, can help the participants align under a common understanding of potential future opportunities and challenges and can lead to higher consensus-building and collaboration.

What is more, when different scenarios are used in a Living Lab, this can lead to the outcomes of the Living Labs being better adjusted and relevant to the needs of the stakeholders. Moreover, the participatory approach to foresight can create a sense of “ownership” and commitment among the

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stakeholders (Inayatullah, 2008), which can increase the chances of a solution proposed by the Living Lab to be implemented.

On the other hand, while the use of foresight methods offers benefits for the Living Labs, there can be a few challenges and limitation regarding it, which need to be considered as well. Firstly, future scenarios are by definition speculative and based on certain assumptions about how things are expected to develop in the future. However, complex systems can often be and act unpredictably. Thus, the accuracy of the assumptions made can sometimes be low.

Secondly, the whole process of creating the future scenarios can become challenging, since the opinions and views of different stakeholders about the future can be far from similar. These differences can be the result of several different factors, such as the professional backgrounds of the various stakeholders, their cultural contexts, and their personal values (Cuhls, 2003). What is more, scenario planning can prove to be a time-consuming process, as well as one that requires significant effort and resources, particularly when involving a wide range of stakeholders. And dedicating substantial time or resources to foresight approaches may not always be a viable option.

Considering the above, the use of scenarios is integrated in Europe-LAND's Living Lab Framework. Trough envisioning, participants are more engaged to express their own view, revealing patterns, sometimes unexpected. During the process, hidden connections can be revealed, allowing the facilitators better understand not only the "what" was expressed but also the "why" behind it. Furthermore, This approach aligns directly to the Project's Specific Objective (SO) 2, as it not only helps understanding the decision-making behind actors' behaviour, but also their perceptions of land uses under current and future climatic conditions.

2. Development of the Europe-Land Living Lab methodological framework

2.1. Methodology for developing a LL Framework

The LL framework outlines a structured framework for an innovation process, divided into several **research stages**, with corresponding **methods & tools** and **outcomes** for each stage (Fig. 5). The process moves from **contextual setting** toward **innovation** and follows a traditional pathway that incorporates the essential components of the LL framework, such as multi-stakeholders, stakeholders' engagement, co-design, co-creation, co-development, real-world settings etc. As a result, key stages include: contextualization (defining the environment, stakeholders, and goals), co-creation (engaging stakeholders in the design and development process), empirical research (testing innovations in real-world settings), evaluation (assessing the impact and feasibility of the innovation). Throughout this process, various methods and tools are used to foster collaboration, maintain a continuous feedback loop, making the LL framework a dynamic and iterative approach to innovation.

The framework provides a comprehensive guide for collaborative innovation, aligning diverse stakeholders through structured methods and producing targeted, actionable outcomes.

The **Context Research** stage is crucial for gathering background information and understanding the broader context in which innovation will occur (Almirall et al., 2012). It supports the development of the LL framework by exploring existing literature, brainstorming, and setting up real-life environments.

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A key aspect of LL planning is **setting a LL leader** who acts as both researcher and facilitator, responsible for engaging stakeholders and guiding research activities (Metta et al., 2022). This phase also involves **problem exploration** and **idea creation** which involves **defining the scope of the LL**. It also includes reviewing the existing LL literature to identify best practices, challenges, and lessons learned, forming the foundation for the current study's objectives.

In a user-driven or utilizer-driven approach (Leminen et al., 2012; Compagnucci et al., 2021), the researcher aligns the process with the specific requirements of the topic, **defining objectives** and **identifying relevant services**, **tailored instruments, tools, and future scenarios**, such as meetings, workshops, demonstrations, and focus groups. Since LLs operate in both simulated and real-world settings, selecting a real-life environment is crucial (Soini et al., 2023). This stage establishes the overall context for developing the initial **LL framework**.

Stakeholder mapping provides an overview of all relevant stakeholders to be engaged in the Living Lab, following the Quadruple Helix Model (citizens/users, government/policy makers, industry, and academia). It involves identifying potential target groups and mapping individual stakeholder profiles, roles, responsibilities, goals, and relationships (e.g., value flows) (Kalinauskaite et al., 2021). Once mapped, stakeholders collaborate to define the scope and develop a **common vision**, aligning expectations and goals. The result is a detailed description of stakeholders, their roles, relationships, and shared objectives.

Co-design & co-creation bring stakeholders together to collaboratively define the project's objectives, scope, and vision, aligning interests and ensuring the project meets user-centered needs. This phase focuses on developing the structure, processes, and methods, often through **design thinking workshops** that identify tools and technologies for collaboration. It includes selecting the right digital platforms or apps for effective interaction for **co-creation.** It involves collaborative activities with multiple stakeholders contributing to the innovation process, making it a key innovation activity within Living Labs (Kazadi et al., 2016; Hossain et al., 2019).

Co-development focuses on collaboratively building the solutions or innovations identified in the co-design phase. It involves defining activities, setting targets, and planning resources while integrating stakeholder feedback through **scenario-building workshops**. These workshops help co-create scenarios, identify challenges, and anticipate benefits. The outcome is small-scale, real-life demonstrations that are then scaled up or down. The result is a collaboration roadmap outlining activities, resources, scheduling, and specific targets.

Roadmap definition focuses on creating a strategic, actionable plan for implementing the project's outcomes. Building on the collaboration roadmap, it translates ideas into tangible steps, guiding stakeholders in executing the co-created strategy. The roadmap defines key actions, milestones, responsibilities, and anticipated outcomes to achieve the shared vision within a specified timeframe. It bridges the planning and implementation phases, leading to the development of tools, innovative solutions, and policy recommendations to support the initiative (Kalinauskaite et al., 2021).

Co-valuation focuses on assessing the outcomes of the innovation process, measuring impact, and identifying areas for improvement. It involves a feedback loop to refine solutions, using both qualitative (e.g., interviews, focus groups) and quantitative methods (e.g., indicators). Data analysis, involving suitable statistical tools, helps identify areas for improvement, and stakeholders participate in follow-up workshops to discuss refinements. Co-evaluation is essential for ensuring continuous

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innovation, as the LLs approach operates iteratively, with each loop improving the previous one (Kalinauskaite et al., 2021). This stage fosters scaling, implementation, and ongoing improvement.

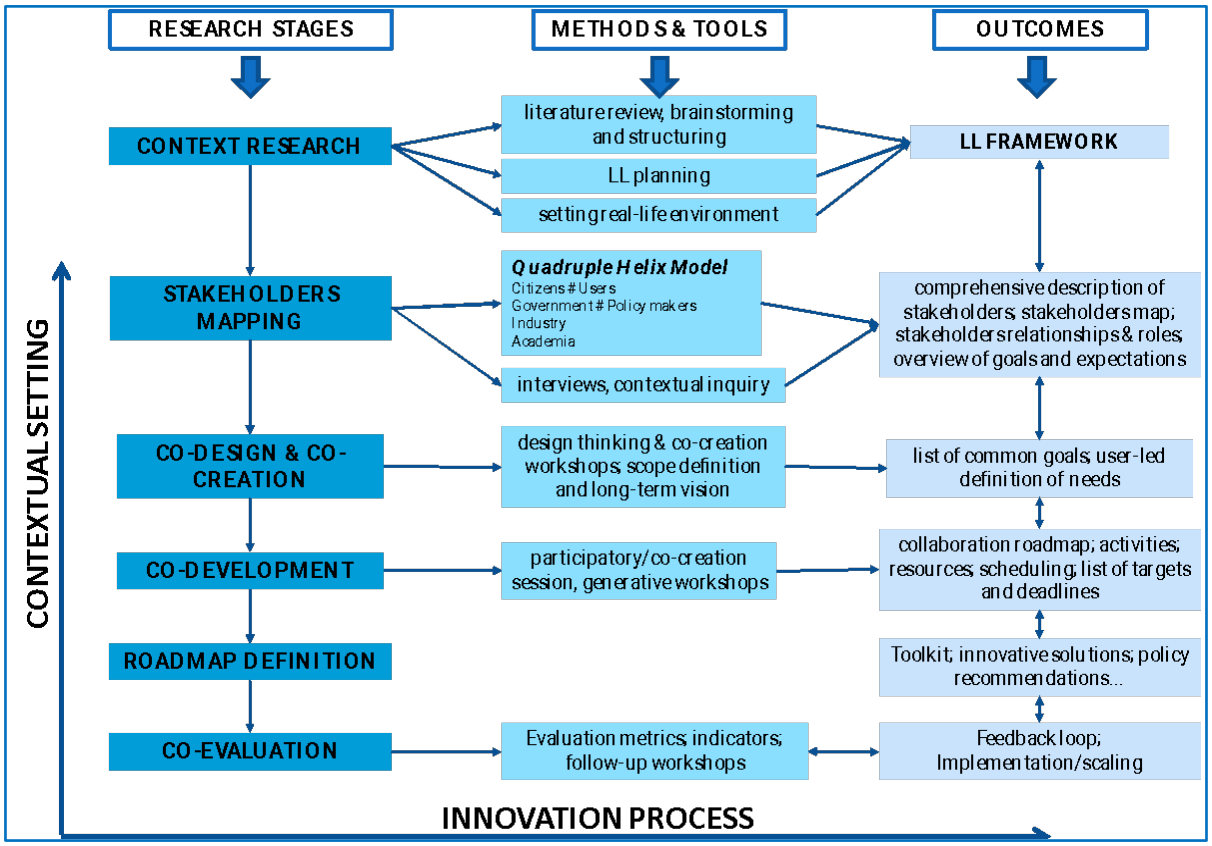

Fig. 5 General features of a Living Lab framework (Own design based on stages identified in the literature)

The transition from research and stakeholder engagement to co-design, co-creation, co-development, and co-evaluation emphasizes the iterative nature of the LL framework. This approach fosters collaborative innovation, ensuring all stakeholders have a voice and solutions are user-centered and scalable. Methods like design thinking, co-creation, and the Quadruple Helix Model integrate perspectives from citizens, industry, academia, and government. The feedback loop enhances adaptability, making the approach effective for initiatives that must respond to stakeholder needs and real-world challenges.

The framework is guided by two main components: the Contextual Setting and the Innovation Process.

The **Contextual Setting** provides the foundation, focusing on understanding the environment, stakeholders, and challenges that shape the context. This setting lays the groundwork for the innovation process, ensuring that the approach is grounded in reality and addresses real-world needs.

The **Innovation Process** transforms insights from the Contextual Setting into practical solutions. Iterative and collaborative, it moves through design, development, roadmap definition, and evaluation. Emphasizing co-creation, co-design, and continuous feedback, it ensures solutions are effective, user-centered, and adaptable.

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2.2. Development of the Europe-Land Living Lab methodological framework

Based on the extensive literature review performed in previous chapters and taking into account the specific needs and research questions of various Europe-LAND tasks, a comprehensive methodological flow has been established for the development of the LL framework. This approach integrates insights from the existing studies while aligning with the objectives of Europe-LAND, ensuring that the framework is both theoretically grounded and practically applicable. The methodological framework outlines the key steps of the LL approach derived from the literature, including co-design, real-life experimentation/real-life environments, co-creation, co-evaluation, and iteration, facilitating its participatory and dynamic process. Through this structured yet flexible approach, the LL framework aims to foster innovation, engage stakeholders, and deliver solutions tailored to real-world contexts. This framework is designed to be flexible and adaptable, allowing it to be tailored to the specific characteristics of each case study. However, it aims to follow the key steps of the LL framework and maintain a central focus on land management issues within the context of climate change. Furthermore, the LL framework was designed as such to help co-designing the Europe-LAND Toolbox, which is one of the main deliverables of the project (D6.1).

The literature review performed in section 1 allowed for defining the main features and theoretical frameworks of the living labs with a focus on social aspects and sustainable development. From this respect, the Europe-LAND approach is close to the features of rural and agricultural living labs as defined by Cascone et al (2024), Gardezi et al (2024), Ceseracciu et al. (2023), as place-specific frameworks that often involve using an integrated approach, as for example a system innovation or a sustainability-related approach. As emphasized by the authors, rural living labs' features require a broader system-thinking approach than the regular LL, with more complexity involved, which requires longer timelines for co-creation and social learning. However, as emphasized in the literature, in designing LL initiatives, efforts should focus not only on definitions and frames, but also on designing or operationalising living labs that are 'flexible, adaptive, context-specific, and guided by robust theoretical foundations' (Ceseracciu et al., 2023). Moreover, LL approaches should be adapted to the various contexts of the respective LL thus guaranteeing the efficiency of the chosen methodologies (Cascone et al., 2024). Moreover, the same authors view LLs not only as laboratories for testing and validating techno-scientific solutions, but also as dynamic systems that support social learning, encourage stakeholder engagement, and enable co-creation, while helping to navigate complexity and uncertainty.

The active engagement of stakeholders in agricultural LLs is essential for fostering open innovation (Verloop et al., 2009). Building on this, the LL framework developed in the Europe-LAND project aims to enable collaboration and knowledge exchange among the Quadruple Helix actors. This framework will support the co-creation and co-development of sustainable agricultural practices, enhance climate change resilience, and accelerate the adoption of innovative, locally adapted solutions. By bridging the climate knowledge-action gap, the Europe-LAND project seeks to relate research and practice, promoting a dynamic environment that empowers stakeholders to contribute directly to sustainable agriculture. As such, the main theoretical foundation of the Europe-LAND project, besides the living lab general frame, lies in various frameworks underlying land use system theories that are considered throughout its WPs. A detailed synthesis of middle-range theories on structural changes in the land use system is presented in the paper of Mayfroidt et al. (2018), which provides an extensive overview of theories governing human-environmental interactions and sustainability science. In this respect, theories of socio-ecological feedback, which aim to understand the land use dynamics based on the

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interactions between human and ecological factors, are the ones closely linked to the Europe-LAND objectives and to the scope of developing the Living Lab Framework.

In this regard, Europe-LAND living lab framework aims to embed the living lab principles and approaches into all WPs and tasks in two ways: either being used to provide a deeper explanation and understanding of the project's results through the multi-stakeholder interaction or to use the results of various WPs to sustain the participatory process, to increase the stakeholders' awareness and gain insights into multiple perspectives that may be open during the dialogue. It has been designed as a practical framework, context-specific considering the project's objectives, flexible and adaptive throughout the project life.

The following **methodological flow** has been established in the elaboration of the Europe-LAND LL Framework (Fig. 6):

1. Analysis of the living lab literature (as presented in chapter 1)
2. Co-creation through consultation among partners (defining the common vision): integration of the needs and research questions of all other WPs to co-create a common vision
3. Characterisation of the case studies in terms of land use and land management context, previous interaction with the stakeholders (previous co-creation efforts), the socio-economic environment, scope definition and co-creation of common pathway
4. Identification and mapping of the stakeholders based on common guidelines
5. Develop the Co-Creation Roadmaps to target national, regional and local level stakeholders (Fig. 7)
6. Organise the first co-creation workshop with national stakeholders
7. Co-evaluation of the effectiveness of the LL activities and the sustainable land management options using evaluation metrics, socio-economic indicators, follow-up workshops

The Europe-Land Living Lab Framework combines the principles of Living Lab approaches as identified in the literature review section, following the 5 pillars of transdisciplinary co-creation research: co-design, co-creation, co-development, co-evaluation. In its construction, we used the action design research and reflection-in-action approach, as suggested by Ståhlbröstand Holst (2017) for the living labs, in order to make the distinction between the innovation aspects of the LL and its research component of reflecting and learning. As such, the proposed framework is flexible and will be continuously adapted and upgraded during the project, as learning and understanding are shaped by a continuous reflection process involving the partners in the interaction with the stakeholders, to adapt the methods, tools and research design based on stakeholders' knowledge interest and experience.

In this approach, we rely on the previous experience gained by the partners in using participatory methodologies in other research projects to adapt the proposed methodology to the socio-cultural specificity and challenges of each country and gain multiple perspectives on how to approach the objectives of the project.

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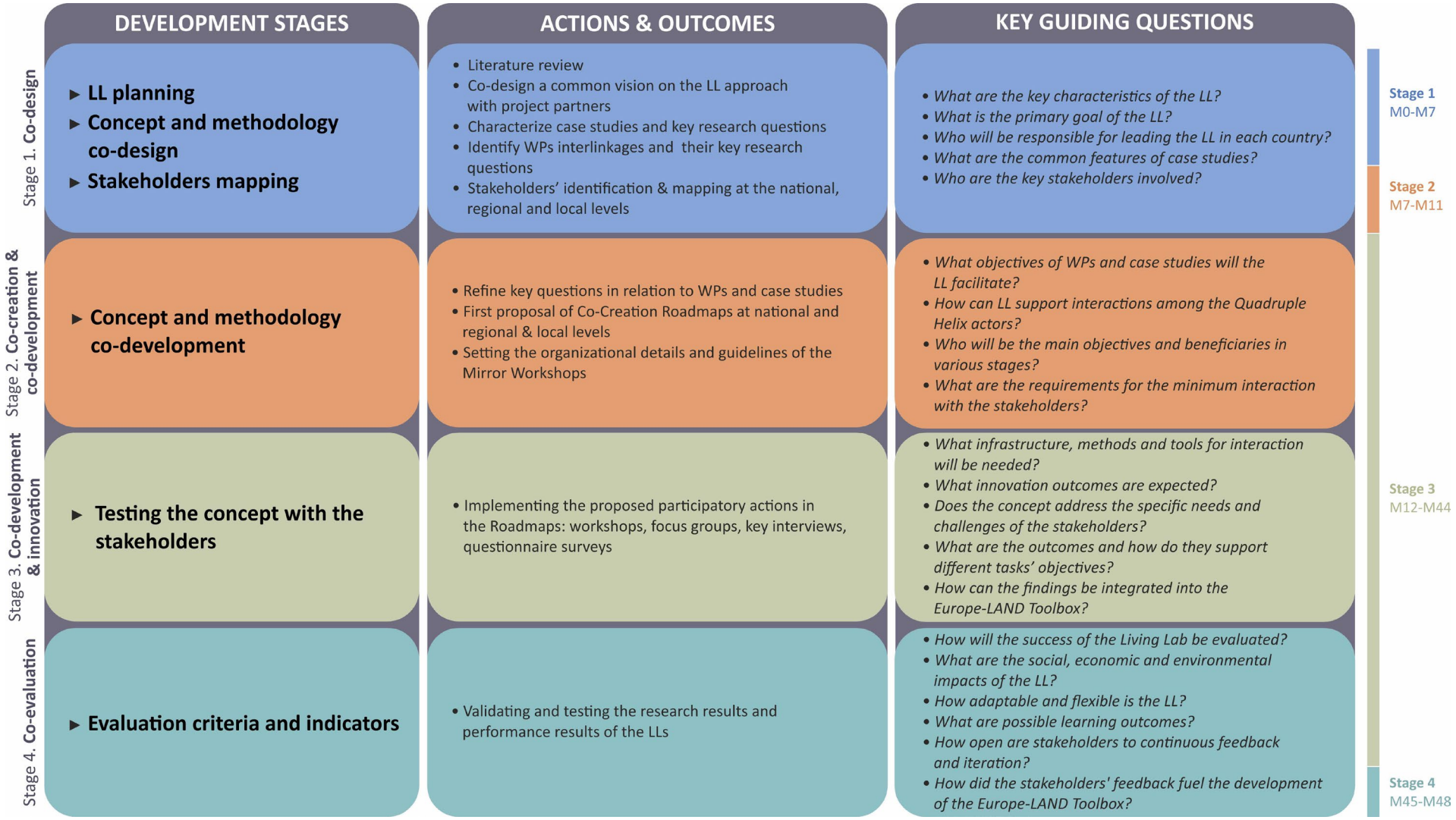

Fig. 6 Europe-LAND LL Framework: main stages, specific objectives, and key questions

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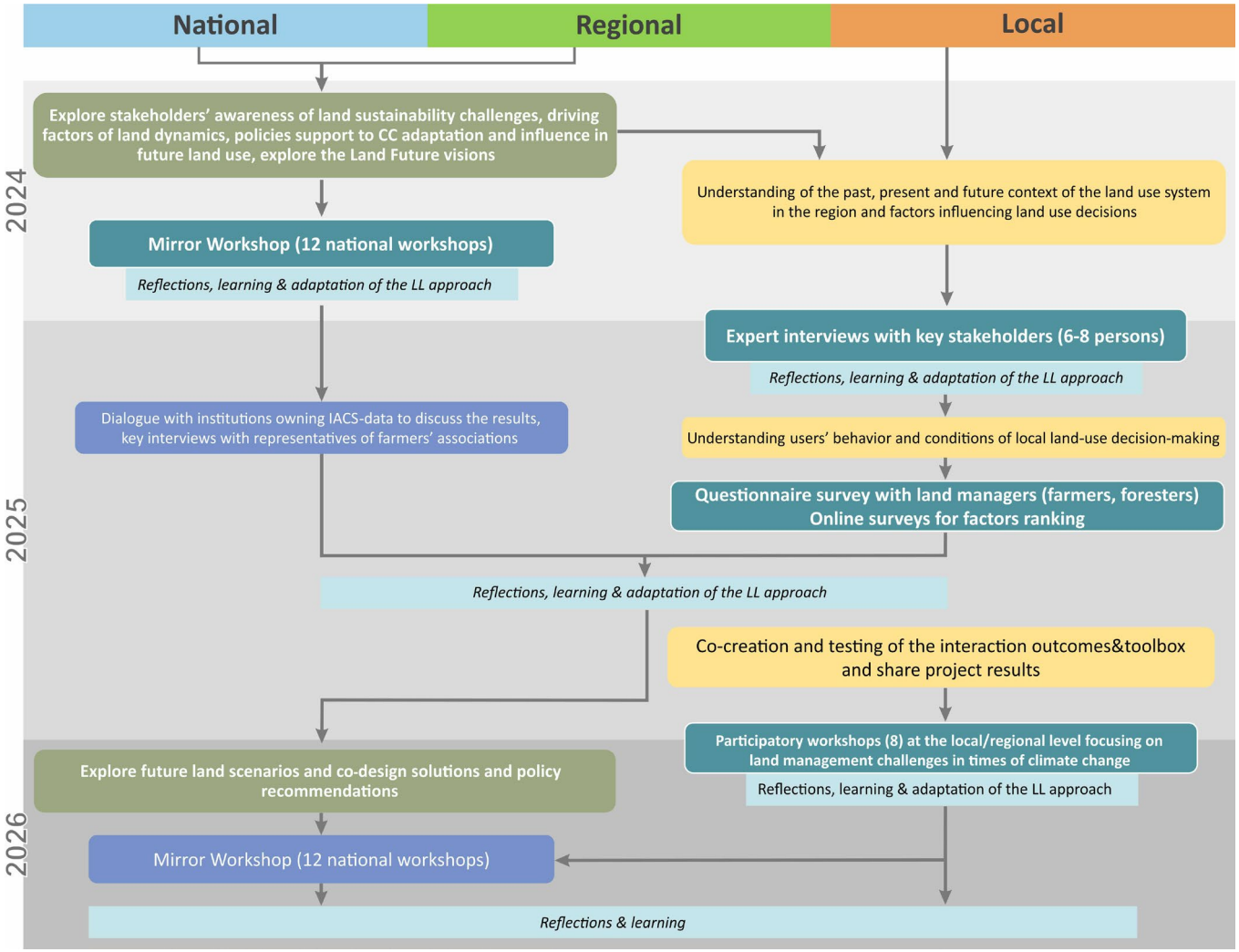

Fig. 7 Co-creation Roadmap at national, regional and local levels

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The first stage, co-design (M0-M7) aimed to create a common understanding of the Living Lab approach across the project and define our role as researchers in the LL setting. In this respect, various consultation activities using design thinking techniques have been promoted first with WP3 task leaders to jointly find ways to implement living lab principles across case studies developed in T3.3 and T3.4. Moreover, each WP defined its research questions and identified the ones that can be involved or be supported by the participatory actions planned with the stakeholders, as such to focus more on the interlinkages between various WPs (Fig. 8). A detailed perspective on WPs' research questions of Europe-Land is included in Deliverable 1.2 of the Europe-LAND project.

Case study leaders have been provided with a questionnaire to assess the specificities of Europe-Land case studies in terms of land sustainability challenges, their maturity level in terms of previous engagement of the stakeholders, methods and tools and specific research questions of mutual interest.

Based on this planning, a series of objectives and associated research questions have been considered as relevant to be addressed during the stakeholders-related activities (specifically targeting participatory actions at regional and local scales, in connection with case studies), as emphasized in the Roadmap, which covers the following topics: understanding local and regional land-use context and dynamics, understanding the agricultural land behaviour and main factors contributing to it, strategies that farmers use for climate change adaptation, the role of agro-environmental schemes to improving farmers wellbeing and factors influencing their orientation towards environmental goals, sustainable land management practices in agriculture and forestry, a better understanding of the role of biodiversity conservation in climate change and protected areas management challenges, exploring diverse future scenarios with stakeholders.

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Fig. 8 Interlinkages between different WPs in terms of relevance for LL approaches

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The second stage, co-creation & co-development (M7-M11) focused on refining the key questions and establishing a preliminary plan in terms of a Co-Creation Roadmap, to be followed by the partners in the project, to target the 3-level focus of the project, meaning national, regional and local levels. In this respect, the Roadmap establishes some minimum requirements for interaction with the stakeholders, allowing for a comparison across countries and case studies. Apart from these, partners are free to propose and organize other activities that involve stakeholder participation.

The **Co-Creation Roadmap** proposes at the national level two categories of interactive activities: participatory workshops (2024, 2026) and key interviews with national stakeholders, aiming to explore stakeholders' awareness of land sustainability challenges, driving factors of land dynamics, policies support to climate change adaptation and influence in future land use, explore the Land Future visions, as well as to explore future land scenarios and co-design solutions and policy recommendations.

The Co-Creation Roadmap at the Regional/Local Levels (for Case Studies) is directed into understanding of the past, present and future context of the land use system in the region and factors influencing land use decisions; understanding users' behaviour and conditions of local land-use decision-making, as well as co-creation and testing of the interaction outcomes & toolbox and share project results. It proposes several participatory actions, as for example to organise expert interviews with key stakeholders (4-6 individuals) at the end of 2024 – beginning of 2025; a questionnaire survey for land managers and organization of workshops for the case studies in 2025. The questionnaire survey will also include questions co-developed with WP6, targeting the development of the Europe-LAND toolbox.

The first participatory action proposed in the Roadmap at the national level was the organization of the first co-creation workshop, across all 12 partners' countries. The workshop was titled the *'Mirror Workshop'* due to its consistent organization, focus, and format across the participating countries and its results are reported in the current deliverable.

The third stage, co-development & innovation (M12-M30) spans a longer period, aiming to implement the proposed Roadmaps at national, regional and local levels and engage creatively and interactively with the stakeholders.

- Finalizing the Mirror Workshop and analyse the results
- Organization of key expert interviews for the case studies
- Organise the questionnaire surveys with land managers, in various stages, both in person and online
- Organise participatory workshops for the case studies
- Organise the 2nd Mirror Workshop at the national level
- Co-develop the narratives of the scenarios with the stakeholders

The last stage, co-evaluation, aims to test and validate the projects' results through various actions:

- Validating and testing the results obtained for case studies and co-created concepts with local/regional level stakeholders
- Validating and testing the project's results during co-creation workshops towards the end of the project
- Identifying solutions for sustainable land management
- This stage will also involve the identification and use of various indicators, along with conducting feedback workshops and interviews to evaluate project's outcomes. Additionally,

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this stage will include assessing the project's impact and sustainability through: Evaluation of the approach and co-created concepts
- Evaluation of the performance of the living-lab activities
- Reflecting on the living lab approach
- Summarizing and reporting the created concepts during WP3 reporting

After each stage, continuous evaluation will be conducted to refine and enhance the approach. This iterative process will involve gathering feedback from all actors within the Quadruple Helix model to ensure that the solutions being developed are adaptable, effective, and aligned with the stakeholders' needs and expectations. By consistently addressing the challenges at each stage and learning from each phase, the approach will demonstrate the flexibility and adaptability of the Europe-LAND LL framework, facilitating its continuous improvement.

Participatory design and co-creation are central aspects of the LL Framework, which aims to embed the living lab principles across all interactive activities with the stakeholders. As such, stakeholders are not regarded as end-users of the project, but are considered active actors involved in co-production of knowledge and orienting various task approaches, co-design of future visions and scenarios, testing the Europe-Land Toolbox and co-design its functionalities based on their needs, validate different results obtained in the project, engage stakeholders in co-creating solutions for land sustainability challenges.

A wide range of methodologies and tools are involved across the proposed participatory events, including co-creation workshops, interviews, discussions, surveys. These approaches are designed to engage all participants actively, ensuring that their insights and feedback are effectively integrated into the LL framework and roadmaps. Additionally, innovative techniques and tools such as scenario planning, future visions, STEEPVL methods will be employed to foster deeper understanding and collaboration among stakeholders. Moreover, the LL Framework will support the implementation of the Telecoupling Framework developed in WP5.

The methodological framework was first tested in the first co-creation ‘Mirror” workshop planned for the national stakeholders for all 12 partners’ countries in the project, using a similar approach. Whose results are presented in section 3 of this report.

2.3. Ethical aspects of the LL interaction

As previously discussed, a Living Lab can be described as a gathering of people actively exploring a specific concept from different perspectives, ultimately reaching a conclusion about a subject. In other words, as Pieter Ballon and Dimitri Schuurman mention in their paper “Living Labs: concepts, tools and cases“ Living Labs (LL) refer to co-creation and appropriation of innovations by users, often in a community setting that can be online or offline (Ballon & Schuurman, 2015). To achieve this co-creation environment, facilitators must ensure that participants not only come from different backgrounds, such as research, business, citizen organisations, and public administration, but also feel safe to trust their thoughts to the researchers.

Thus, ethical aspects are crucial in Living Labs, as ethical risks related to participant privacy, informed consent data security, and equitable impact are amplified. The basic principles that were integrated in the design of the Europe-LAND Living Lab framework are as follows:

- Protection of Participant Rights and Privacy
- Transparency and Informed Consent

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- Equity and Inclusivity
- Sustainability and long-term impact

Protection of Participant Rights and Privacy. Living Labs (LLs) operate in open and real-world settings involving stakeholders from different backgrounds. As a result, the protection of participant rights and privacy must be a top priority for the facilitators, who should take into consideration strong protections around how participant data is collected, stored, and used, to avoid compromising individuals' privacy and autonomy.

Firstly, participation in Living Labs must be voluntary. As a result, facilitators must ensure that participants join voluntarily after fully understanding the concept of the upcoming Living Lab and how the LL's results will be used for the purposes of the Project. Furthermore, participation must take place after having the participants' informed consent, meaning that the latter are aware of the data being collected, the intended uses, and potential risks, as well as having the opportunity to opt-out or opt-in anytime they need to do so, maintaining autonomy over their involvement.

To implement the above, the Project Consortium has elaborated a Participant Consent Form, that needs to be agreed on by the potential Stakeholders. More precisely, after stakeholders were identified and selected to join the Living Labs events, participants were personally informed by the facilitators regarding the Project, the purposes of the upcoming workshop and how its results will be used in the Project. The Consent Form was translated in national languages and informed the signees in detail about the data collected and how these data will be handled and used. It clearly stated that their information will be treated with utmost sensitivity and will be stored in a restricted access folder on the project repository. The Participant Consent Form complied with the General Data Protection Regulation (GDPR) of the EU.

Consequently, the organised Living Labs adhered the principles of openness and transparency. Participants understood the project goals, methodologies, and potential impacts. Furthermore, their data were protected and anonymised prior to utilisation.

Equity and Inclusivity. Living Lab facilitation should serve as collaborative spaces that efficiently address the problem stated. To do so, participant selection must be based exclusively on affiliation and background and not on gender, abilities or other criteria that may exclude them from participating. This is extremely important when integrating participatory approaches, as each activity must be open to anybody that meets the expertise or representation criteria set by the facilitators.

Participants, in general, are to be selected based on frameworks that guide innovation ecosystems, such as the Quadruple or Quintuple Helix Model. After longlisting Stakeholders from the different subsystems, one can draft a short-list of invitees by more specific criteria, such as professional background in relation to the issue examined in each Living Lab.

For the purposes of the Project, the Consortium held an introductory meeting to familiarise the Project's partners with the concept of Living Labs. During the workshop, the ethical aspect of Living Labs was introduced mentioning that:

- Living Labs must be a safe space, where participants are and feel free to express their point of view
- Facilitators must try to maintain gender balance among the participants
- Hate speech and discrimination are prohibited

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Sustainability and Long-Term Impact. The Living Lab Framework actively aligns with the United Nations Agenda 2030 and its Sustainable Development Goals (SDGs) by fostering inclusive, participatory activities that respect not only the data shared by participants but also honour their unique perspectives and contributions. This approach prioritizes the protection of participant privacy, cultivates a respectful and transparent environment, and ensures that the Living Lab serves as a space where diverse voices are valued and upheld.

By creating an environment where participants feel like integral parts of the project, the framework encourages ongoing engagement and commitment. Participants are empowered to see how their input and insights contribute directly to the project's activities, strengthening their connection to the project's objectives and increasing their motivation to stay involved. This sense of ownership and shared purpose ultimately leads to a more dynamic, sustainable, and community-focused innovation process.

2.4. Characterization of Europe-LAND case studies

There are 8 case studies as demonstrators in Europe-LAND project, located in different environmental regions of Europe as indicated in Figure 9 aiming to provide an in-depth understanding of land users' behaviour and conditions of local land-use decision-making. As such, several criteria have been considered for selecting the case studies since the proposal:

- Main focus to be agriculture, forestry and protected areas
- To include a trade-off between conservation and land use, thus 5 protected areas from Germany, Czechia, Portugal, Poland and Romania being considered
- To have a previous connection with LTSER sites: case studies from Slovakia, Austria and Romania being linked to that
- Ideally to have a previous connection with the stakeholders

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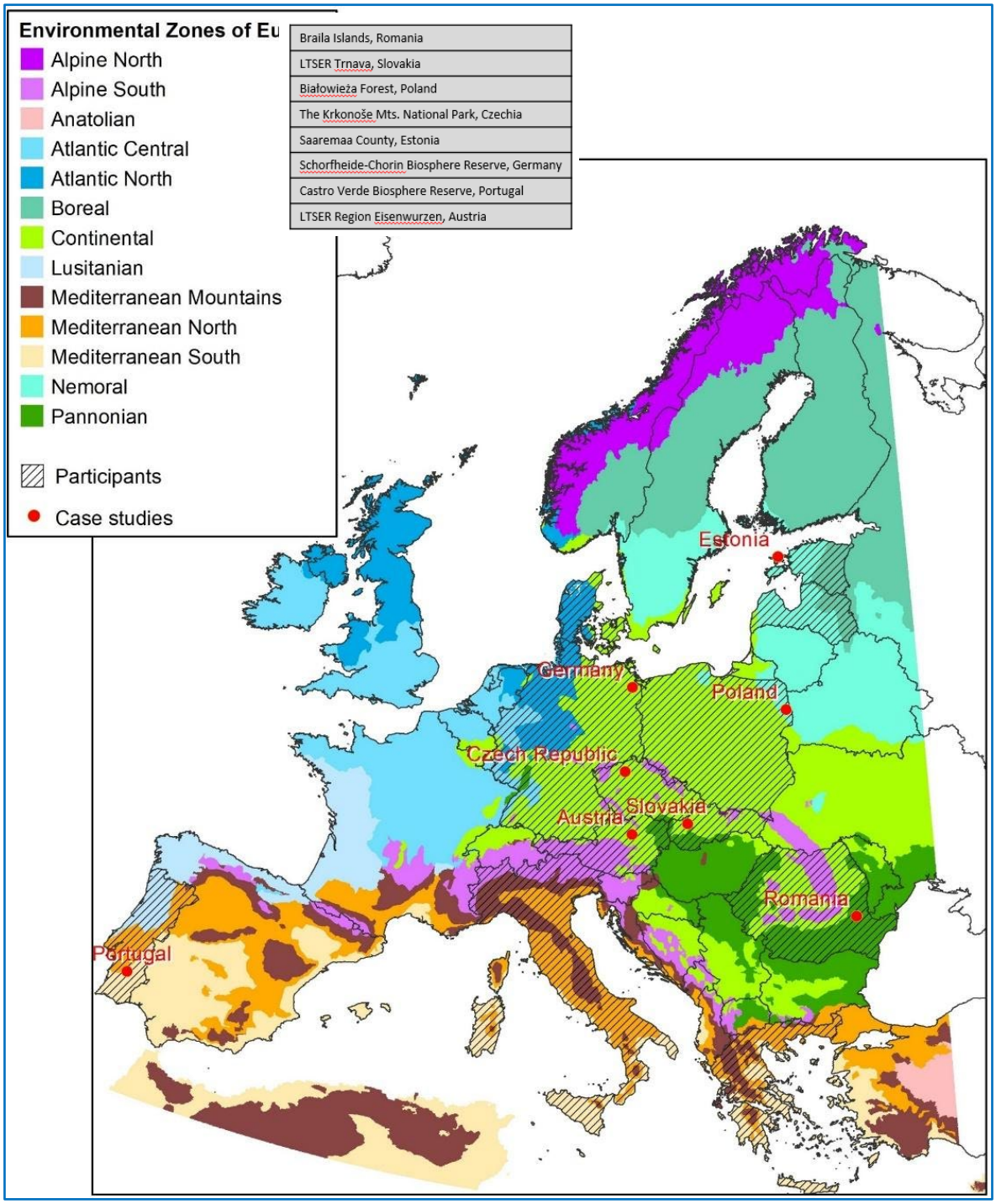

Fig. 9 The location of Europe-LAND case studies. Map background: The Environmental Stratification of Europe dataset (Copyright holder: European Environment Agency (EEA)[3]

An important step in proposing the living lab approach for the case studies in Europe-LAND was to gain a good understanding of their particular features. In this respect, a standard questionnaire has been prepared and filled in for each case study, that targeted a short characterization of the case study context in terms of geographical location, context, land use pattern, land management, past and current land use change, specific research questions, the most pressing and relevant issues related to

[3] https://sdi.eea.europa.eu/catalogue/idp/api/records/6ef007ab-1fcd-4c4f-bc96-14e8afbcb688

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land decisions, main stakeholders groups, previous connection with the case study, whether there have been some previous co-creation activities with the stakeholders, methods and tools planned to be used, experience in terms of co-creating scenarios with stakeholders.

It can be noticed the variety of case studies, that target specifically the local level (e.g. Czechia) or are extended over a larger region (e.g. Austria), with main focus on agricultural or forestry land use. Most of them can be considered at a mature level since a previous interaction of the partners with different stakeholders' groups have been done in previous projects, as well as a certain co-creation level as the specific research questions to be investigated for some case studies being based on stakeholders' needs (Table 2).

Table 2 An overview of Europe-LAND case studies

No	Name of the case study	Country	Surface	Main focus	Previous connection with the stakeholders	Co-created research questions
1	LTSER Region Eisenwurzen	Austria	5,904 km^2	Agriculture+forestry+ protected areas	Yes	Yes
2	The Krkonoše Mts. National Park	Czechia	42 km^2	Protected area (forestry)	Yes	Yes
3	Saaremaa County	Estonia	2,938 km^2	Agriculture+cultural landscape	Yes	No
4	Schorfheide-Chorin Biosphere Reserve	Germany	1,300 km^2	Protected area (forestry, agriculture) – biosphere reserve	Yes	Yes
5	Białowieża Forest	Poland	1,250 km² (580 km² Polish side)	Protected area (forestry) – world heritage	Yes	Yes
6	Castro Verde Biosphere Reserve	Portugal	567,2 km^2	Protected area (biosphere reserve)+agriculture	Yes	Yes
7	Braila Islands	Romania	970 km^2	Agriculture+protected area (wetland)	No	No
8	LTSER Trnava	Slovakia	364 km^2	Socio-economic drivers of LUC, community-oriented	Yes	No

A description of the eight case studies included in Europe-LAND is provided in the section below. This overview offers insight into the environmental and socio-economic context of each case study, highlighting key land use patterns, historical and current land use characteristics, land management practices, and the most pressing challenges for land sustainability. Case studies are presented considering the alphabetical order of countries.

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LTSER Region Eisenwurzen, Austria

Partner responsible for the case study:
Institute of Social Ecology, University of Natural Resources and Life Sciences, Vienna

Geographical location of the case-study

The LTSER Region Eisenwurzen is located in the center of East Austria and borders the federal states Lower Austria (Niederösterreichf), Upper Austria (Oberösterreich) and Styria (Steiermark) (Fig. 10 and Fig. 11). The region is defined by the geographical coordinates of 13.88° to 15.50° E longitude and 47.29° to 48.25° N latitude.

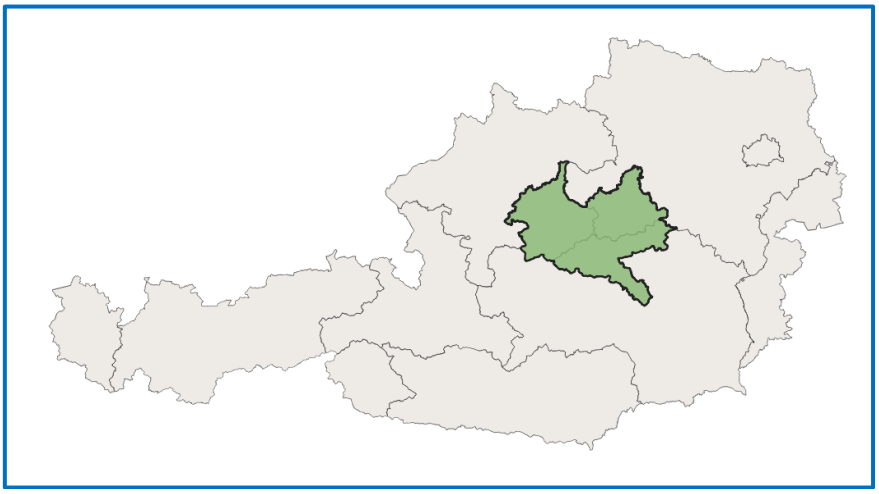

Fig. 10 The location of the Eisenwurzen study site (dark green) within Austria; boardering der federal states Upper Austria (top left), Lower Austria (top right) and Styria (lower part) (data.gv.at, 2023b)

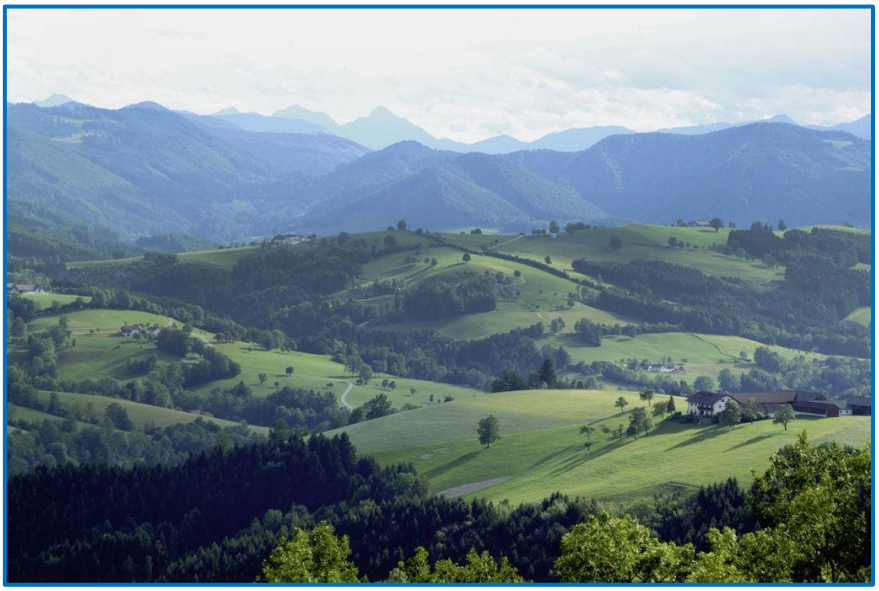

Fig. 11 Landscape photograph of the Eisenwurzen region showing the transect from hilly to high mountainous grassland and forested landscapes. (LTSER Platform Eisenwurzen, 2023)

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Short description of the case-study/Context

The study region Eisenwurzen covers a total 5,904 km2 and offers diversity in both landscape and topography (DEIMS-SDR, 2023). While the northern fringes are lowlands with 250-500 m a.s.l, the landscape transitions from hilly-terrain to alpine mountains in the centre of the study regions with elevations up to 2,445 m a.s.l. (data.gv.at, 2015). The study region lies within the continental climate zone with annual mean temperatures ranging from -1.1°C to 9.6 °C annual precipitation variations between 730 mm and 2,202 mm (GeoSphere Austria, 2023).

Corresponding to the topographic variations, the land use systems in the Eisenwurzen are quite diverse. The northern borders are characterized by intensive crop production, while the hilly and mountainous areas have high shares of forest and extensive grasslands.

The study region includes 91 municipalites and 311,243 inhabitants (as of 01.01.2023; (data.gv.at, 2023a; Statistik Austria, 2023). Settlement areas are concentrated in the northern and southern outlines of the study region with spares population density in between. The socio-economic centers of the study region are concentrated in the areas surrounding Steyr in the northwest and Wieselburg in the northeast.

The regions tourism focuses on nature experiences, as there are two national parks (Kalkalpen and Gesäuse), along with the nature and geopark Steirische Eisenwurzen, which were all founded between 1996 and 2002. The region has a long lasting history in iron mining that also served as its namesake as ‘Eisenwurzen’ translates as ‘root of iron’ (Stieber & Oberösterreichische Landesausstellung, 1998). Many tourist activities are themed along the historic ‘Eisenstrasse’ (iron road) where iron used to be transported along and the old traditions from this mining era. Since 2018 the customs and traditions of mountain huts belonging to the ‘steirische Eisenstrasse’ (styrian iron road) are UNESCO cultural heritage (Immaterielles UNESCO Kulturerbe, 2023). Current and future challenges for the region include the emigration of people from mountainous areas and the abandonment of remote agricultural lands. Furthermore, there is a strong trend towards transitioning to organic production. Climate change has divergent effects on the region, on one hand, it leads to an extension of the growing season, and on the other hand, increasing numbers of extreme events adversely affect agricultural production.

Land use pattern

About 50% of the Eisenwurzen region is covered by forests (Copernicus, 2012). In 2021, there was a total of 125,757 ha of agricultural land, spread over four agricultural main production areas (Alpenvorland, Voralpen, Hochalpen and Alpenostrand). The region consists of 34% cropland and 66% permanent grassland, of which 10% are mountain pastures (GeDaBa, 2022c). In 2010 there were a total of 8105 farms in the region. In 2021, about 5560 farms participated in IACS agri-environmental schemes, of which 29% were organic farms. About 60% of the farms were cattle livestock farms, 16% were forestry farms and about 10% were processing and cashcrop farms, with the remainder being other forms of farms such as permaculture (GeDaBa, 2022c). As typical for Austria, farms are run as family businesses. The livestock numbers for the region come at about 160 tsd livestock units (LSU), of which about 60% are cattle and about one-third pigs and small shares of sheep, goats and poultry (GeDaBa, 2022d).

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Land management

Areas with intensive cropfarming are concentrated in the lowlands in the top north of the study region. Most important crop cultures in the region are grain maize and winter wheat that together accounted about 40% of total cropland in 2021 (GeDaBa, 2022b). Grassland consists of about 55% intensive grasslands (3 and more cuts, respectively 1.5 LU/ha stocking density) and 45% of extensive grasslands (mountain pastures and meadows with 1-2 cuts, respectively <1.5 LU/ha stocking density) (GeDaBa, 2022b).

Austria has strong regulations regulating the application of fertilizer. Due to the high share of farms that participate in the ÖPUL programme (Austrian IACS), 'conventional farming' refers mainly to farms that adhere to these guidelines particularly concerning fertilization (BML, 2022). Additionally, about 85% of grasslands are exclusively fertilized by manure (Buchgraber, 2018).

Past and current land-use trends

According to the agricultural structure survey, the number of active farms decreased by -15% between 2000 and 2010, with a share of about 10% for forest farms (without agricultural areas) in 2010 (GeDaBa, 2022a). However, the number of organic farms increased by +21% from 2000 to 2021 (GeDaBa, 2022e). While the total agricultural area decreased by -11% between 2000 and 2021, the area under IACS-schemes has doubled and the share of organic areas increased to 30%. Cropland remained relatively stable (-3%) during this period, whereas permanent grasslands decreased by -15% (GeDaBa, 2022c).

What are the most pressing and relevant issues related to land use and land use decisions in your case study area?

- Land abandonment and forest transition and its implications for biodiversity
- Factors that affect the participation in agri-environmental measures
- Land-use decisions and their effects on the well-being of local farmers
- Future of nature-based solutions in response to climate change.

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The Krkonoše Mts. National Park - Czechia

Partner responsible for the case study: Charles University, Prague (CU)

Geographical location of the case study

The case study will take place in the Krkonoše Mts. – located in the northern part of Czechia. The main area of our case study will be the small red area – around Pec pod Sněžkou which is a watershed of the upper Upa river (Fig. 12 and Fig. 13). The area is located partly in the national park and partly outside the national park (Fig. 14). Size of the study area is around 42 km^2.

Fig. 12 The geographical location of the Krkonoše Mts.

Fig. 13 Landscape features of the Krkonoše Mts.

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Fig. 14 Landscape features of the area outside the national park

Short description of the case-study/Context

The landscape character is dominantly shaped by permanent natural conditions, especially the rugged mountain relief of the highest Czech mountain range with large height differences, long slopes, deep valleys and glacial modelling of the highest parts. Added to this is the historical development of the landscape into forest and non-forest areas and the settlement pattern with today's mainly recreational function. Particularly significant and visually attractive are the technical facilities for winter sports and recreation, such as ski lifts, cable cars, ski slopes, snow cannons, etc. A unique natural and landscape phenomenon are the Krkonoše ridges and high plains above the upper forest boundary with a cover of boulder stone seas, isolated rocks and tor-type rock walls (e.g. Mužské kameny, Dívčí kameny, Ptačí kameny, Violík), the source area of the Elbe (Labská louka, Pančavská louka) with high mountain peat bogs and stands of knotweed, the cascading Elbe waterfall and the glacier-modelled Elbe mine with meanders of the Elbe and the rocky northern slopes of Zlatý vrch vrch or the characteristic silhouette of the Kotel with glacial karst (Malá and Velká Kotelní jáma) on the southern side. The landscape and vegetation cover is dominated by spruce forests, with disconnected knotted woodland above the upper forest boundary and mown mountain meadows in the secondary forest-free area.

Residential buildings are concentrated only in the core of the mountain resorts in deep valleys (Rokytnice nad Jizerou), otherwise they are scattered on the slopes in irregular groupings of mountain houses, original farmsteads, mountain huts, hotels and individual recreational buildings (Rokytno, Hoření Domky, Horní Mísečky, Dolní Mísečky). In the higher mountain altitudes above 1000 m above sea level, there are only individual mountain huts and lodges that are isolated and distant from each other (e.g. Dvoračky, Vrbatova bouda, Vosecká bouda and the largest "Labská bouda"). Numerous memorials to the victims of the mountains, winter pole markings and, on the inner Bohemian Ridge, abandoned concrete bunkers as a remnant of the border fortifications built between 1935 and 1938 complete the landscape in detail.

The summit areas of the Krkonoše above the upper forest boundary resemble the landscape of the Scandinavian mountains or the Arctic tundra in northern Scandinavia in their landscape character, relief and vegetation cover (subalpine tundra), which is why the Krkonoše Mountains are also called the 'island of the Arctic in central Europe'. Their character is unparalleled elsewhere in Central Europe.

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The Giant Mountains were a traditional area of mountain farming in the past centuries. It has always had the least arable land of our mountain ranges, which is related to the large spread of pastoralism, rational forestry, the development of industry in the valley settlements and the early start of tourism, which reached its greatest intensity here (Häufler, 1955). However, the area of Upper Rokytnice and Lower Rokytnice belongs to the areas of traditional mountain agriculture with a significant share of arable land in the past. The higher mountain positions, including the Border Ridge above the upper forest boundary, were gradually used from the 16th century onwards for seasonal mountain pastoralism, which was similar to Alpine pastoralism adapted to local conditions. The experience of mountain grazing was brought here by colonists from the Alpine countries who were brought here as woodcutters. They developed pastoralism on cleared land, mainly grazing cattle. From the 17th century, but mostly in the 18th century, summer mountain huts were built (e.g. Dvoračky, Martin's hut, huts in Rokytno and many others). Most of them were built at an altitude of 1000-1300 m. The summer huts were not only used for grazing, but also for harvesting hay.

The decline and eventual demise of mountain pastoralism occurred in the mid-19th century with the gradual banning of grazing in the forest (1866) and the banning of grazing above the upper boundary of the forest (1897). At the end of the 19th century, it was decided to plant slash and burn to prevent avalanches. For longer than grazing, occasional mowing and hay harvesting, common even in the First Republic, was maintained. The mountain huts were converted into holiday cottages for summer and winter recreation and hiking, and many of them have also disappeared. The removal of the original German population after World War II (1945-1946) and the declaration of the Krkonoše National Park (1963) contributed to the complete end of agricultural use of the Krkonoše Mountains.

The change in the Krkonoše landscape can be characterised as follows:
I. the original natural forest landscape with subalpine kneeling forests at the highest altitudes above the upper forest line changed from the 16th to the 18th century into a landscape of mountain agriculture (arable and pastoral, at higher altitudes exclusively pastoral), with a high proportion of forest preserved;
II. mountain farming and deforestation reached its peak in the 18th century and by the mid-19th century; from the mid-19th century onwards, mountain farming declined, arable land and pasture land declined, the proportion of forest increased, and the landscape changed from a productive forest and agricultural landscape to a recreational landscape;
III. the current landscape is dominated by recreational and sporting use and its primary nature conservation importance (Krkonoše National Park).

We will focus on major challenges that include agricultural and forest management inside and outside the national park. Inside the national park issues like nature preservation rules have to be followed within the management – for example, management of invasive/expansive species that has to follow the rules. Further bark beetle issue, farmers and their collaboration with NP Administration, zones without management, tourism and its impact on conservation (hotels, ski slopes, number of tourists, etc.), industrial production and its influence of water/rivers, mining activities and their influence.

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Land use pattern

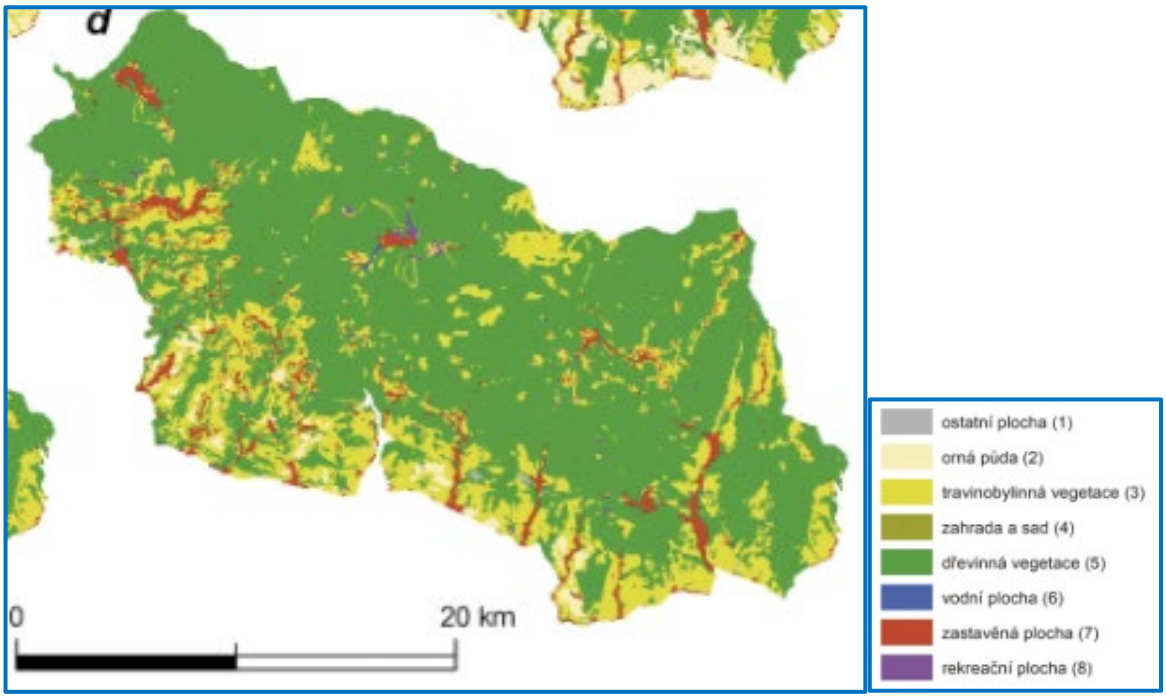

Fig. 15 Land use pattern
Legend: 1 other area, 2 arable land, 3 permanent grasslands, 4 orchards, 5 forests and shrubs, 6 water area, 7 build-up area, 8 recreational area

Dominating land use – forestry. Farms are mainly oriented on grasslands and livestock, in lower parts on crops (Fig. 15). The evaluation about the number, size and types of farms will be part of the research of the case study as no relevant data are available.

Land management

There are:
- Zones without management (discussion about return of some ways of management)
- Agricultural management inside and outside national park – different ways according to the different restrictions of nature preservations (all types of management – grazing, pasture, mulching, management of invasive species), arable land in lower parts – fertilization, herbicides
- Forest management – partly managed by national park and partly by private owners or state; partly in the zone without management

Past and current land-use trends

From the 1990s to the present. The 1990s brought major changes to the agricultural sector. The original state farms and the unified agricultural cooperatives were broken up and successor entities began to emerge. States livestock numbers declined to the point where that many grasslands lost their forage

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value. The grazing of young livestock ceased cattle imported from the Podkrkonoší region to the mountains for summer grazing.
In the eastern Giant Mountains, the much of the meadows and pastures were not harvested, including those that had been restored in the past associated with intensive fertilisation, produced large quantities of high-quality biomass and were easily accessible to conventional mechanisation. At the contradiction between the lack of livestock and the surplus of grassland, the Ministry of Agriculture responded with subsidies aimed at landscape maintenance. Farmers received funding if they harvested grassland. The large-scale mulching of mountain meadows, which consists of crushing the grass and leaving it in place.

The new method of landscape maintenance has been very beneficial for farms in areas with low soil fertility. One sufficiently powerful tractor was able to handle the growing season of land in a single growing season. The cost per hectare was calculated at around CZK 1,000, while subsidies were available for CZK 3,000-4,000, depending on the area. For this reason, many farms held land they did not need for livestock feed. The rules on subsidies were tightening: in order to receive a subsidy, you had to a conventional farmer had to show at least 0.3 LU (livestock units) per hectare (a LU is equivalent to 500 kg of live weight of animals, which is roughly 1 cow, 1 horse or 5 sheep). Tightening of the conditions for obtaining subsidies was intended to eliminate farms that farmed on permanent grassland without owning any livestock. A significant role in this respect was also the newly emerging ecological agriculture, where the minimum requirement for subsidies was set at 0.1 DJ per hectare.

Agricultural holdings with insufficient of livestock have opted for solutions to become an organic farm, thus achieving an increase in subsidies per unit area and thus higher profitability of farming. Paradoxically, organic farming thus encouraged mulching grassland to a greater extent than conventional farming. As farming checks were carried out on farms in the autumn, a significant proportion of the crops were mulched in August and September. This late mulching has a positive effect on grass development the same effect as when the land is to leave it without any intervention). However, late harvesting of grassland creates ideal conditions for reproduction of the field bindweed.

Today, mulching is no longer allowed for subsidy purposes, yet in many places it is applied in a modified version - cattle are first driven over the vegetation, and then only the 'undergrowth' is mulched. Currently, the park and its protective zone, more than 1,800 ha of agricultural land is managed under the organic farming system. The unprofitability of arable farming of arable land and the profitability of subsidies for grassland maintenance the majority of arable land in the buffer zone has been grassed over. There is now less than 500 hectares of arable land are registered forage and fodder crops predominate for feeding market cows with milk production.

Following the Czech Republic's accession to the EU in 2004, the principles of the Common Agricultural Policy began to be applied, the main objective of which is to improve food safety and quality, animal welfare and the relationship between agriculture and the environment. A major change was the introduction of the so-called 'milk production policy'. A major change was the introduction of soil blocks, in which land is registered, on which farming takes place. Farmers can only receive all payments and aid on land entered in the register soil block register. On the basis of this register and other specifying conditions, farmers are granted direct payments and aid from the Horizontal Rural Development Plan.

In 2005, the soil blocks covered by subsidies were granted by the Ministry of Agriculture, most of the permanent grassland crops. Additional areas of grassland in the park managed by users who did not meet the conditions for obtaining subsidies allocated by the Ministry of Agriculture were supported by the Landscape Care Programme provided by the Ministry of the Environment (in 2005 this was approximately 500 ha).

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Long-term LULC trends are indicated in the picture:

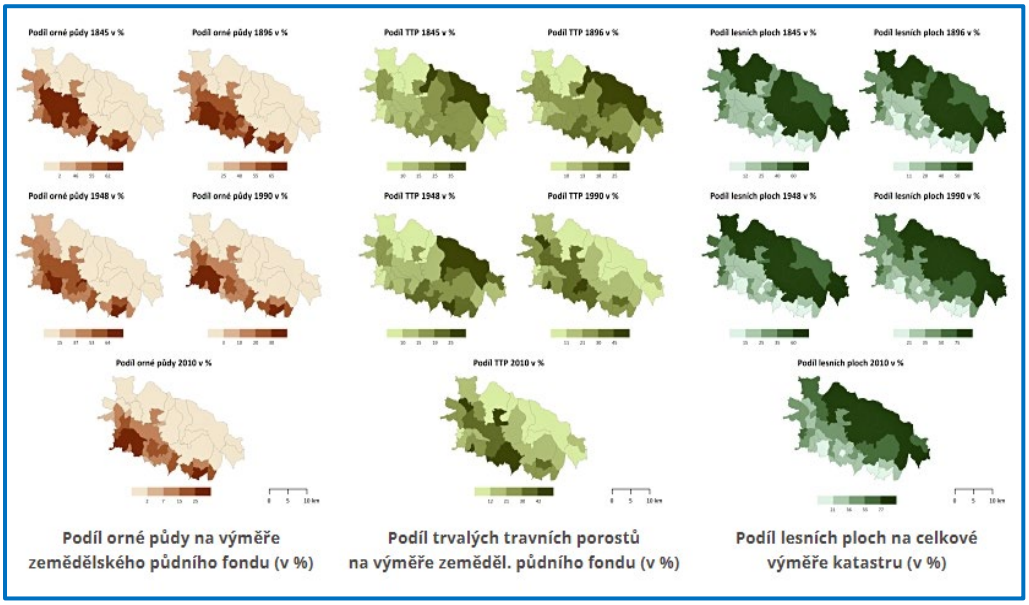

Fig. 16 Share of agricultural land and forests
Legend: Brown – share of arable land on agricultural land, bright green share of permanent grasslands on agricultural land, dark green – share of forests on total area

What are the most pressing and relevant issues related to land use and land use decisions in your case study area?

1. Influence of the national park – impact on the management of forests and agricultural land
2. Natural conditions and climate change in connection to national park preservation and management practice
3. Subsidies and their influence on land management inside and outside the national park
4. Forest calamities and their influence of forest management in the zones with and without management
5. Overtourism - in the Krkonoše Mountains overtourism is a significant issue, with the region seeing over 6 million visitors annually. This immense pressure on the region's natural resources highlights the need for sustainable tourism practices to preserve the landscape.

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Saaremaa County, Estonia

Partner responsible for the case study: Estonian University of Life Sciences (EMU)

Geographical location of the case study

North-Eastern part of the Baltic sea, West from the Estonian mainland (Fig. 17).

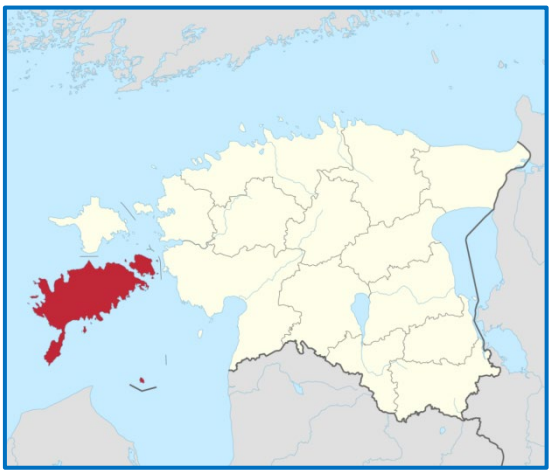

Fig. 17. The location of Saaremaa County (red)

Short description of the case-study/Context

The Saaremaa county is one of the 15 counties of Estonia with the area of 293 832 ha (2,938 km2). It consists of Saaremaa (2,673 km2), the largest island of Estonia, and several smaller islands near it, most notably Muhu (198 km2), Ruhnu (11,9 km2), Abruka (8,8 km2) and Vilsandi (9,0 km2) (Fig. 18, Table 3). In 2022 Saare County had a population of 31,292, which was 2.4% of the population of Estonia.

The county is subdivided into 3 municipalities (in Estonian: vallad – parishes).

Fig. 18 Saaremaa Island (Estonia)

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Table 3 Municipalities in Saare County – Saaremaa, Muhu and Ruhnu

Rank	Municipality	Type	Population (2018)	Area km^2	Density
1	Muhu Parish	Rural	1,946	206	9.4
2	Ruhnu Parish	Rural	160	12	13.3
3	Saaremaa Parish	Rural	31,819	2,705	11.8

The West Estonian islands are low-lying plains that have limestone as base rock covered by thin moraine layer. The area is flat with average elevation roughly 15 meters above sea level. The highest point is Viidumägi (54 m a.s.l.). The limestone is covered mainly by some meters of moraine sediments. In some areas surface layer is only some centimetres that forms specific habitat type – alvars that are mainly found in Sweden and Estonia. Alvars have very thin sediment layer – less than 30cm, that makes these habitats very dry and calcareous and that have uniquely high plant diversity. Historically these alvars were mainly grazed, especially with sheep. In the region, another specific land-use type has been wooded meadow that was extensively managed (cut by hand and grazed by livestock) (Table 4, 5 and 6). The later type of meadows with single trees has one of the Europe richest plant diversity as well. Islands also feature coastal meadows that historically were extensively managed and are characterized of highly specific biodiversity impacted by their coastline location. All these valuable semi-natural habitats have overgrown with trees during the last century because of declining or disappearing traditional management practice. Nowadays lot of efforts are put to restoring these habitats. Due to their outstanding bio- and landscape diversity, these islands have lot of protected areas and areas with high nature value. The county has the highest percentage of ecological/green farming in Estonia (Table 7). The region is considered for the UNESCO biosphere reserve.

Because of unique nature, the region needs sustainable and well-balanced economic activities, especially agriculture, to save natural value, at the same time to provide income to the local people. The main focus is given to the ecological farming and tourism that attracts many people around the world.

Table 4 Landuse classes of cadastral units in Saare county registry data by Estonian Land Board (Maa-amet, 31.08.2023)

	ha	%
Cultivated land:	55943,60	19,04
Natural grassland:	22548,90	7,67
Forests land:	167250,80	56,92
Yard areas:	4426,50	1,51
Other:	43090,30	14,66

Table 5 The characteristics of agricultural farms in Saare county by Agricutural Registers and Information Board of Estonia (PRIA), 2023

	Estonia	Saare County	% of Estonia
Agricultural land	978973	62495	6,4
Number of farmers	13152	1047	8,0
Average area in ha per farmer	74,4	59,7	80,2

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Table 6 Cultivated crops in Saare county, 2022

	Saare ha	% from Saare total	Estonia ha	% from Estonian total
Grassland gramineae	36961	65,2	285542	12,9
Grassland legume	5494	9,7	134651	4,1
Legume crops (peas etc)	907	1,6	50842	1,8
Fallow land	113	0,2	6180	1,8
Vegetables	57	0,1	1423	4,0
Strawberry	10	0,0	627	1,6
Oil and fiber crops	3475	6,1	97034	3,6
Herbs and medical plants	29	0,1	1054	2,8
Potatoes, beet, cabbage	81	0,1	3912	2,1
Cereals	9477	16,7	387457	2,4
Fruits, berries	110	0,2	3220	3,4

Table 7 The characteristics of organic farming in Saare county by by Agricutural Registers and Information Board of Estonia (PRIA), 2023

organic farming 2022	organic		conventional		total applied area
	ha	%	ha	%	ha
Estonia	202522	20,9	766375	79,1	968897
Saare county	16832	29,8	39674	70,2	56506

The share of Saare county organic farmers from whole Estonian organic farmers is 10,7%. The share of Saare county organic agricultural land from whole Estonian organic agricultural area is 8,30% (Table 8).

Table 8 Organic and non-organic animals in Saare county 2022

	organic	nonorganic	total	share of organic
Pigs	0	30368	0	
Beef cattle	5188	6234	11422	45,4
sheep	6322	4744	11066	57,1
diary cattle	374	4663	5037	7,4
beehive	405	3934	4339	9,3
goats	45	186	231	19,5

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After restoration of Estonian Republic, the former ownership (before the Soviet occupation) was restored and lands were given back to the former owners. The former farms were rather small, and in many cases the former farms were divided between many heirs, therefore lots of land owners with relatively small area of land were established. Importantly, most of them were not living in the area. Therefore, a large share of land is rented by landowners to farmers who are directly involved to cultivating agricultural lands. Most of them are professional farmers, however, there are several hobby farmers too, especially on islands who usually manage semi-natural areas by cutting or grazing.

Land management

Because of high shares of grasslands and organic farming, a broad diversity of management practices is applied. The most common ones are hay harvesting (also for silo production) as well as beef cattle and sheep grazing. Grasslands are fertilized only by manure. Grasslands can be renewed but not plowed. In case of ecological farming no artificial fertilizers and chemicals are allowed. No irrigation is used in the area.

Past and current land-use trends

Most of the area of Saare county has been in under various agricultural uses. However, due to prevailing thin soil cover, agriculture has not been very intensive. About century ago the main agricultural activity was grazing and hay making on the grasslands and wooded meadows. During the Soviet Time (after 1945) more intensive agricultural practices had been introduced. Yet, the thin soil cover did not allow for high yields. Nevertheless, many grasslands have been converted to croplands. Since the independence in 1991 the farming practice has changed again. The share of grasslands increased, the number of beef cattle and sheep increased again.

An important land use feature of the area is raising coastline levels that results in the expansion of the terrain, closing bays and emergence of new coastal wetlands etc.

What are the most pressing and relevant issues related to land use and land use decisions in your case study area?

Threats to biodiversity and cultural landscapes under changing land use preferences and agricultural practices.

Underexplored sustainable management practices for decreasing carbon footprint and adapting to climate change.

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Schorfheide-Chorin Biosphere Reserve, Germany

Partner responsible for the case study:
Leibniz Institute of Agricultural Development in Transition Economies (IAMO)

Geographical location of the case study

The Schorfheide-Chorin Biosphere Reserve (SCBR) is located northeast of Berlin, in the federal state (Bundesland) of Brandenburg, Germany, near the Polish border (Fig. 19). The coordinates 13.45° – 14.20° E longitude and 52.80° – 53.15° N latitude mark the boundaries of the Reserve[4].

Fig. 19 Location of the Schorfheide-Chorin Biosphere Reserve & typical landscapes (Map source: Wikipedia; Photo above: @Z.; Photo below: @M. Flade)

Short description of the case-study/Context

The Schorfheide-Chorin Biosphere Reserve is one of the largest protected areas in Germany, encompassing an expansive area of 1,291 km^2. The Reserve is composed of a Core area, Buffer Zone, and Transition Area—in line with the regulation of UNESCO Biosphere Reserves, with area proportions of 2.8%, 18.7%, and 78.5%, respectively (Committee, 2005).

[4] https://www.schorfheide-chorin-biosphaerenreservat.de/en/; Schorfheide-Chorin Biosphere Reserve - Wikipedia

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This unique Reserve, designated as a UNESCO Biosphere Reserve in 1990, represents a harmonious blend of natural beauty (e.g., the harmonious forests, 240 lakes and numerous small water bodies and moors) and rich socio-economic heritage[5].

Climate: The climate is transitional between temperate-oceanic and sub-continental, with average annual temperatures ranging from 8 to 9°C. With annual rainfall between 480mm – 580mm, the Schorfheide-Chorin Biosphere Reserve is one of the driest regions in Germany.

Landscape: The Reserve is situated within a youthful morainic region, encompassing all the geomorphic features and elements of a glacially formed landscape (e.g. till plains, terminal moraines, outwash plains, basins).

Diverse Ecosystems: The Reserve boasts an array of ecosystems, including beech and pine forests, fields, waterbodies and moors (Committee, 2005). These habitats support a wide range of flora and fauna, making it a biodiversity hotspot in the region.

The vegetation and biodiversity are relatively well protected. For example, studies show that there has been little vegetation change and no significant reduction of species in recent years in the dry grassland complex at the Gabower Hänge in the Reserve (Hüllbusch et al., 2016). With years of conservation efforts, the Reserve has seen an increase in large mammals, such as moose and wolves (Ostermann-Miyashita, et al., 2022).

Wetlands and Water Bodies: The presence of wetlands, peat bogs, and marshes within the Reserve plays a crucial role in maintaining the ecological balance. These areas provide habitats for numerous plant and animal species while also serving as a natural carbon sink.

Birdlife Haven: The Schorfheide-Chorin Reserve is a haven for birdlife, attracting both local and migratory species. The region's forests, wetlands, and water bodies make it a vital stopover point for migrating birds.

Highlights of Socioeconomic and Cultural Side
Cultural Heritage: The Reserve is steeped in history, with cultural landscapes, historical buildings, and archaeological sites that reflect the region's human history spanning centuries.

Tourism: The natural beauty and cultural attractions draw tourists (especially from Berlin), providing economic opportunities for local communities. Sustainable tourism initiatives have been vital in maintaining the delicate balance between conservation and socio-economic development.

Current and future challenges:
As most of the protected areas, the challenge is to balance environmental conservation and economic development. The SCBR faces several challenges in preserving its unique ecosystems and biodiversity while addressing sustainable land use, climate change, and socio-economic development. The Reserve still has a large proportion of agricultural land within the Reserve, operated by both small family farms and big farms. Different farming practices may have implications on the nature conservation targets (Meyer-Aurich et al., 2003).

Climate change, especially the low precipitation and heat events, poses major challenges for agriculture and forestry and calls for the adaptation of land-use strategies in response to climatic changes.

[5] Schorfheide-Chorin Biosphere Reserve: https://www.schorfheide-chorin-biosphaerenreservat.de/en/

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Additionally, the Reserve hosts substantial areas of drained peatlands that are used for farming and that continue to constitute major emission sources.

Land use pattern

The land use pattern in the Schorfheide-Chorin Biosphere Reserve is characterized by a blend of agriculture, forestry, and water bodies, reflecting the region's diverse landscapes and the need to balance human activities with environmental preservation (Fig. 20).

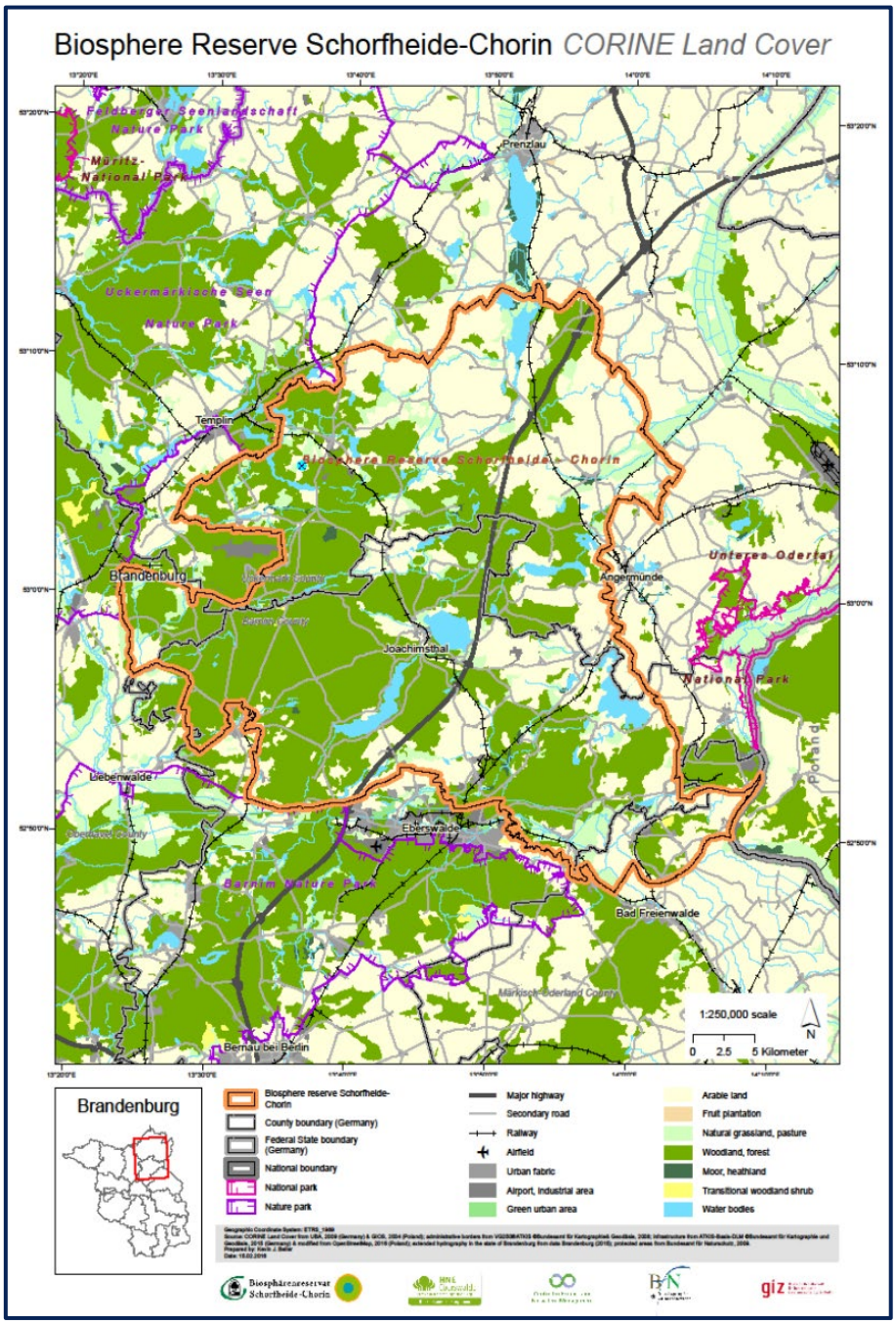

Fig. 20 Land Use & Land Cover Map of the Schorfheide-Chorin Biosphere Reserve (Source: (Christina Lehmann 2016))

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In the Core Area of the Reserve, the ecosystem is strictly protected; agriculture and other human land use activities are prohibited. In the Buffer Zone, moderate land use (e.g., eco-tourism)is allowed. In the Transitional Area or development zone, the land use activities include intensively managed forests and agriculture.

Approximately 62% of the Reserve's land is devoted to agriculture. Agricultural is mainly composed of cropland and grassland. While crop farming is dominating, livestock farming, particularly cattle and sheep grazing, is also common. About 29% of agricultural land is managed ecologically—organic farming[6]. While small farms exist in the region, most of the land is cultivated by medium and large farms (over 25) with more than 500 ha of land, similar to many Eastern German regions.

Farming Types: The most important farming types include cropland (cereal crops such as wheat, barley, and rye), grassland (for grazing and hay production), and livestock farming (including cattle, sheep, and poultry). Diversified farming practices are common.

Land Tenure: The core zone is mostly owned by the state of Brandenburg, a registered society supporting the Reserve. However, a small part, about 28 ha, is owned by private forest owners. The area is reduced continuously with the purchase effort of the state. Forest and agricultural land in the buffer zone are owned by the registered societies, cooperatives, and private land owners.

Forest takes about about 650 km^2 (50%) of the biosphere reserve's area. The forests are dominated by planted pine stands, although the natural potential forest vegetation would be dominated by mixed deciduous trees. Forestry plays a crucial role in the local economy and ecosystem.

Water bodies, including about 240 lakes, take a total area of 90 km^2 (7%); Associated wetlands and numerous peatlands are widely spread in this region.[7]

It's important to note that the Schorfheide-Chorin Biosphere Reserve's land use pattern is subject to regulations aimed at promoting sustainable agriculture and conserving the unique ecosystems within the Reserve, under the UNESCO Man and Biosphere (MAB) program, where Sustainable agricultural and conservation of ecosystems are encouraged. Balancing the economic needs of farming communities with conservation objectives is a key challenge in the area, and efforts are made to encourage environmentally friendly and sustainable land management practices among the farmers in the region.

Land management

Land use is still to be characterized by legacies of former East Germany, including large tracts of monocultural coniferous forests and a large farm structure that emerged from the collective farming system during socialist times. Since 1990, the land use intensity of this former Eastern European region has slowly decreased.

Agriculture: Organic farming and extensive farming are promoted to make the agricultural activities compatible with the conservation targets. About 1/3 of farms are certified organic farmers, managing about 50% of the agricultural area.

Grassland: Land use intensity on grassland varies across the region by the mowing frequency, grazing intensity, and fertilizer usage. The land use types in the grassland include mowed meadows, cattle

[6] https://www.schorfheide-chorin-biosphaerenreservat.de/fileadmin/user_upload/PDF/LfU/Gebietsfaltblaetter_englisch/br_sc_eng2013.pdf

[7] https://service.tereno.net/joomla/index.php/observatories/northeast-german-lowland-observatory/test-sites

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pastures, and a combination of mowing and grazing (mowing pastures). Generally speaking, the land use intensity is less intensive compared to other regions. For example, the average number of mowing per year is around 2, and has a slightly downward trend (Griffiths et al. 2020, Holtgrave et al. 2023).

The land use intensity of grassland has a negative effect on soil's potential as a methane (CH4) sinker, measured by potential atmospheric CH4 oxidation rates (PMORs). Particularly the utilization of fertilizer can lead to 20% reduction in PMOR (Täumer et al., 2021).

According to Socher et al. (2012), grazing has strong negative effects on species richness; moving intensity has slightly negative effects on species richness; surprisingly, fertilizer usage has slightly positive effects on species richness. A more recent study shows a complicated picture of the relationship between land use intensity and biodiversity, where the land use intensity is negatively related to biodiversity, and land use intensity also moderates the relationship between biomass productivity and biodiversity (Andraczek et al., 2023).

Forest: Besides the unmanaged forests primarily in the core zone—where trees are left to grow naturally without intervention, the majority of forests are managed as age-class forests—trees are grouped and managed based on their age to maintain a balanced ecosystem. Forest in the transitional zone can be intensively managed, e.g., through logging practices of mono-culture pine trees.

Past and current land-use trends

Since 1990, the region has been protected as a natural reserve. There is little land cover change within the Reserve. The most prominent change is the change in land-use intensity, which in general, has been decreasing in the past decades with ever-increasing area of land converted to organic farming. Promoting and supporting organic agriculture and forestry play a key role in the conservation efforts of the Biosphere Reserve.

What are the most pressing and relevant issues related to land use and land use decisions in your case study area?

- Climate change adaption by changing land-use strategies and intensities;
- Reducing peatland CH4 emission with optimal land-use practices;
- Optimization of land use to balance the ecological conservation and welfare of local residents, including farms and forest managers.
- Farmers' decision on adoption of organic farming or Agri-environmental measures

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Białowieża Forest, Poland

Partner responsible for the case study: Bialystok University of Bialystok (BUT)

Geographical location of the case-study

The Białowieża Forest is located on the border between Poland and Belarus (Fig. 21), in the Podlaskie Voivodeship in Poland and the Grodno Region in Belarus. Administratively, in Poland, the Białowieża Forest region lies within the municipalities of Białowieża, Hajnówka, Narew, Narewka, and Dubicze Cerkiewne, which are part of the Hajnówka County (NUTS3: PL842). The Białowieża Forest spans an area of 150,000 hectares. The western part, located in Poland, covers 62,500 hectares, while the eastern part in Belarus covers 87,500 hectares (forming the "Belovezhskaya Pushcha" National Park). The village of Białowieża is considered the geographical center of the forest. The location of the Polish part of the forest is demarcated by the coordinates 23°31′ – 24°21′ (E) of eastern longitude and 52°29′ – 52°57′ (N) of northern latitude.

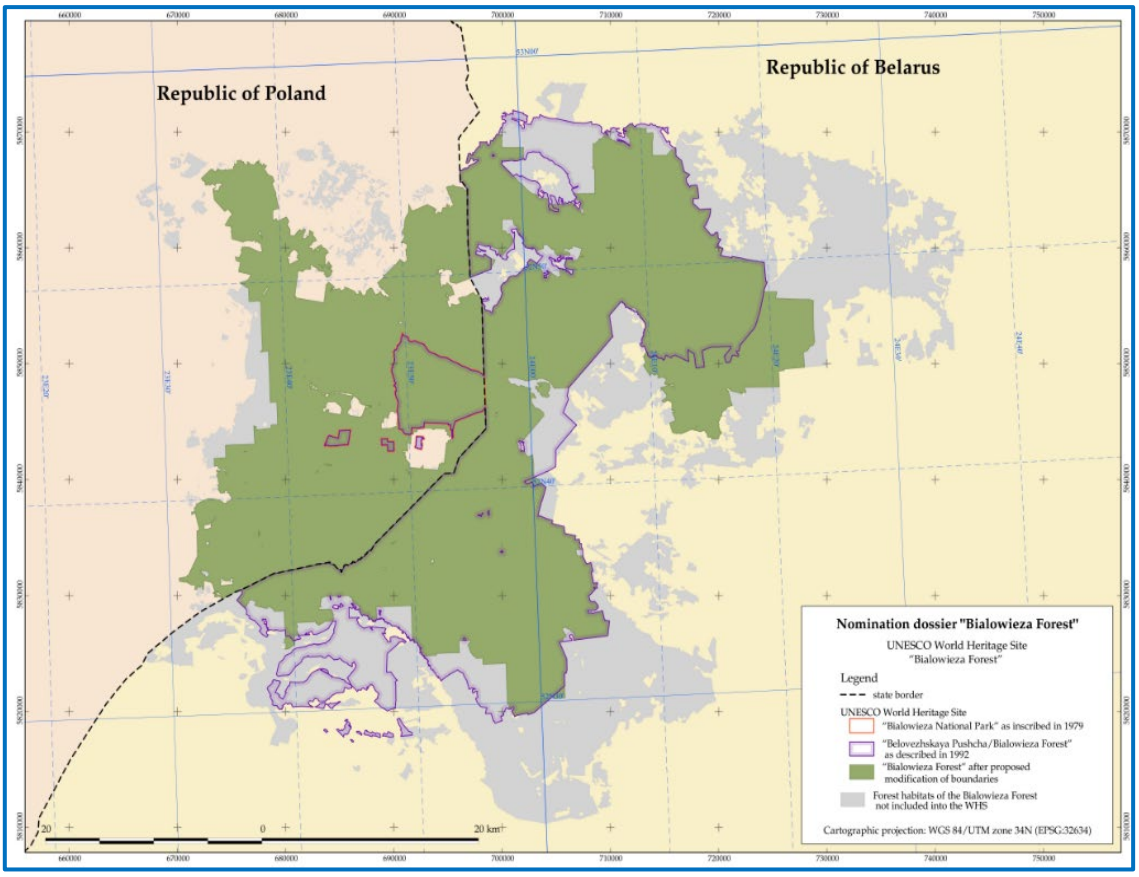

Fig. 21 UNESCO World Heritage Site "Białowieża Forest"
Source: UNESCO World Heritage Convention, https://whc.unesco.org/en/documents/132364.

Hajnówka County (Fig. 22) covers an area of 162,353 hectares. It consists of 9 communes, including one urban commune, one urban-rural commune, and seven rural communes.

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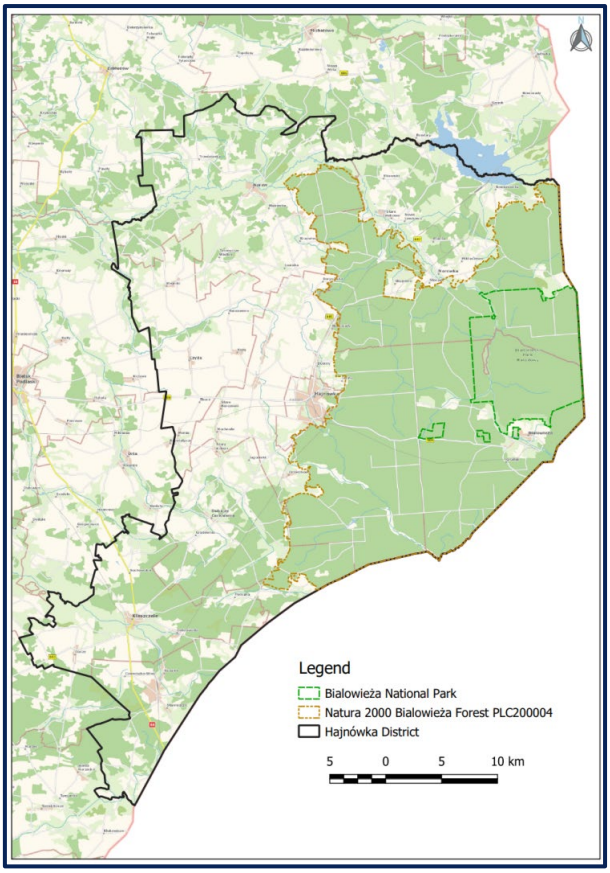

Fig. 22 Location of the Białowieża Forest in Poland
Source: The map was generated using the QGIS 3.28.4-Firenze software (Free and Open Source Software (FOSS); Free Software Foundation, Inc., USA; www. qgis. org). Source for the Database of General Geographic Objects (BDOO) and National Register of Boundaries: goeportal.gov.pl (Terms and conditions: https://www.geoportal.gov.pl/en/about-geoportal/terms-and-conditions/).

Short description of the case-study/Context

The Bialowieza Forest is a unique forest complex on a national, European, and global scale, encompassing the last remaining lowland fragments of natural forests with a primeval character in Europe. The last forest of its kind in the European lowlands, it covers an area of approximately 1,250 km² (580 km² on the Polish side).

Białowieża Forest is characterized by centuries-old, multi-species, and multi-layered tree stands, as well as very high biodiversity (especially at the genetic, species, and ecosystem levels). Bialowieza Forest conserves a diverse complex of protected forest ecosystems which exemplify the Central European mixed forests terrestrial ecoregion, and a range of associated non-forest habitats, including wet meadows, river valleys and other wetlands. The area has an exceptionally high nature conservation value, including extensive old-growth forests. The large and integral forest area supports complete food webs including viable populations of large mammals and large carnivores (wolf, lynx and otter) amongst other. The richness in dead wood, standing and on the ground, leads to a consequent high diversity of fungi and saproxylic invertebrates[8].

Bialowieza Forest is a large forest complex located on the border between Poland and Belarus. Thanks to several ages of protection the Forest had survived in its natural state to this day. The Bialowieza

[8] https://whc.unesco.org/en/list/33/

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National Park, Poland, was inscribed on the World Heritage List in 1979 and extended to include Belovezhskaya Pushcha, Belarus, in 1992.

The most valuable part of the Polish section of the Białowieża Forest (about 1/6 of the area) is covered by the Białowieża National Park (BPN). In 1977, BPN was granted UNESCO Biosphere Reserve status under the "Man and the Biosphere" program, and in 2005, the entire Polish part of the forest was given this status. In 1979, BPN (as the first natural site in Poland) was inscribed by UNESCO on the World Heritage List. In 1992, the status of the site was extended to include the Białowieża Forest in Belarus (creating a Polish-Belarusian transboundary site), and in 2014, it was expanded to include a significant portion of the Białowieża Forest on the Polish side. The transboundary UNESCO World Heritage site, under the name "Białowieża Forest," currently covers an area of 141,885 hectares on both sides of the border, with a buffer zone covering 166,708 hectares[9]. In total, this constitutes an area of 308,593 hectares (the Polish portion covers 59,576.09 hectares, with a buffer zone of 35,834.91 hectares)[10].

The main factors determining the current and future land (forest and agro land) use (in the Białowieża Forest region include: protected area with restrict rules, demographic problem connected with depopulations problems, tourism development, quality of soil.

Land use pattern

Agriculture is one of the most critical sectors of the economy of the Hajnówka County (Raport, 2019), which covers the Bialowieza Forest region. Agricultural land covers approximately 39.1% of the district's area, with arable land making up 20.9% of it (Statistical Office in Białystok, 2023) (Table 9).

Table 9 Use of land in Hajnówka County in 2022

Specification	Area	
	in ha	in %
Total	**163,352**	**100.0**
Agricultural land	**63,922**	**39.1**
of which arable land	34,028	20.9
orchards	114	0.1
permanent meadows and pastures	23,717	14.5
Forest land as well as woody and bushy land	**88,942**	**54.4**
Land under water	1,126	0.7
Residential areas	1,256	0.8
Transport areas	4,576	2.8
Minerals areas	128	0.1
Wasteland	1,716	10.1
Other land	687	4.2

Source: *Environmental protection and forestry in Podlaskie Voivodship in 2022. Statistical information*, Statistical Office in Białystok, Białystok 2023

The average index of the quality of agricultural production space in Hajnówka county is 52.6 points, with the average index for Poland being 66.6 points and the Podlaskie Voivodeship average of 54.3 points. (Biesiacki et al., 2004). Most of the soils in this area are low in nutrients (nitrogen, phosphorus, potassium). It is estimated that the shortages of these components concern about 60% of the

[9] UNESCO, https://whc.unesco.org/en/list/33/

[10] Białowieża National Park, https://bpn.com.pl/index.php?option=com_content&task=view&id=1670

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agricultural land. In addition to the lack of fertile soils, relatively difficult conditions for the development of agricultural production also result from low average annual temperatures, a short growing season, and land fragmentation (*Supralocal Development Strategy…,* 2023).

There are about 8,000 farms (GUS, 2020). These are family farms and their area structure is fragmented: farms with an area of up to 2 ha of UAA - 70% and farms with an area of more than 15 ha - 11%. Larger farms specialized in milk production. Since July 2021, consolidation work has been underway to improve the area structure of farms and forest land. Cereals are dominated in the crop structure. In communes with light soils, a significant part of the arable land is used extensively or periodically fallow, contributing to biodiversity protection (Kiryluk, 2009).

In the Bialowieza Forest region, there are perfect conditions for creating ecological farms producing high-quality food. Organic farming, run by family farms, creates local, independent, and short supply chains but the total agricultural land under organic farming in Hajnówka county is only about 1% (GUS, 2022). The specificity of the region is the extensive forestation. The forest area in the Hajnówka County covers 88,852 ha, and the forest cover index (forest area relating to the total area of the unit) amounts to 53.8%. This is 24.1% higher than the national average, which stands at 29.7% (Table 10). The highest forest cover index is in the Białowieża Commune at 87.9%, and in the Narewka Commune at 67.2% (Statistical Office in Białystok, 2023).

Table 10 Forest land in Hajnówka County in 2022 (as of 31 December)

Unit	**Forest land**						
	grand total		**public**				**private**
	grand total	of which forests	**total**	of which owned by State Treasury			
				total	of which manager by		
					the State Forests	national parks	
ha	**88,852**	87,355	**76,646**	76,441	66,073	9,974	**12,206**
%	**100.0**	98.3	**86.3**	86.0	74.4	11.2	**13.7**

Source: Statistical Office in Białystok, *Environmental protection and forestry in Podlaskie Voivodship in 2022. Statistical information*, Białystok 2023.

In the ownership structure of forest land, public ownership dominates (86.3%), with 86% of the land owned by the State Treasury. The State Forests manage 74.4% of the forest land in Hajnówka County, while the national park manages 11.2% of the county's forest land. Private forest land accounts for only 13.7% of all forest land in the county. The part of the Białowieża Forest managed by the State Forests (the Białowieża, Browsk, and Hajnówka forest districts) is part of the Białowieża Forest Promotional Complex, which covers 52.6 thousand hectares (Regional Directorate of State Forests in Białystok, 2023). The primeval forest represents a lowland forest type, with deciduous, mixed and coniferous stands growing on a moraine plain. The richness and mosaic arrangement of natural habitats ensure a high degree of biodiversity. The most valuable forest community here is the Eastern European oak-hornbeam in fertile habitats (which have been almost completely deforested throughout Europe and are now farmland), but there are also many non-forest, aquatic and peatland habitats.

Forests are covered by various forms of area-based nature protection, such as a national park, nature reserves, the Natura 2000 network and protected landscape areas. Protected areas are on 99,418.7 ha, of which the Białowieża National Park occupies 10,517.3 hectares (6,059.27 hectares are under strict protection, while 4,104.63 hectares are under active protection). Two protected landscape areas are under protection: a forest complex around the Białowieża Forest and a part of the protected landscape of the Narew Valley, with a total area of 88,455.0 ha, and 23 nature reserves covering 12,337.5 ha of land. In the Hajnówka county, 616.1 hectares of ecological land and 1,215 nature

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monuments have also been established. Altogether, protected areas cover about 61.2% of the total area of the district (this indicator is 32.3% for Poland and 31.6% for the Podlaskie Voivodeship). The highest share of legally protected areas in the total area of the district occurs in the Białowieża municipality (99.9%), Narewka (99.8%), Dubicze Cerkiewne (68.9%), and the rural Hajnówka municipality (67.8%). The Natura 2000 area (Special Protection Areas and Special Areas of Conservation) covers 63,147.6 hectares of the Białowieża Forest (Statistical Office in Białystok, 2023).

Land management

In Poland, the Białowieża Forest is managed by the Białowieża National Park (which oversees the most ecologically valuable part of the forest) and forest administration - the State Forests, represented by three Forest Districts: Białowieża, Browsk, and Hajnówka (which manage the Forest Promotional Complex "Białowieża Forest"). The State Forests manage 86.4% of forests owned by the State Treasury, while the Białowieża National Park manages 13%. Forest areas have forest management plans, while national parks have protection plans. The management of the Białowieża Forest area presents a number of challenges, as there are different group of stakeholders with different: interests, vision, and goals e.g. forest authority, national parkauthorities, local citizen, NGOs, tourists.

Protection and management of the transboundary World Heritage site "Białowieża Forest" require strong and effective cooperation between the States Parties, and also between institutions in each State Party. The Bialowieza National Park (Poland), the Polish Forestry Administration and the Belovezhskaya Pushcha National Park authorities have entered into an agreement regarding preparation and implementation of an integrated management plan for the nominated property, and to establish a transboundary steering group. In addition, the State Party of Poland has developed an agreement establishing a Steering Committee between the National Park and the Forest Administration aiming to achieve a coordinated approach to integrated management. It is essential to ensure the effective functioning of this Steering Committee, including through regular meetings, and its input to transboundary coordination and management. It is essential that the national parks of both States Parties maintain effective and legally adopted management plans, and an adopted management plan for the Bialowieza National Park (Poland), to support its inclusion in the property, is an essential and long-term requirement.

It is essential to ensure that the integrated management plan for the property addresses all key issues concerning the effective management of this property, particularly forest, meadows and wetlands management, and that it is adequately funded on a long-term basis to ensure its effective implementation. Effective and well-resourced conservation management is the main long-term requirement to secure the property and maintain the necessary management interventions that sustain its natural values. Threats that require long-term attention via monitoring and continued management programmes include fire management, the impacts of barriers to connectivity, including roads, firebreaks and the border fence. There is also scope to continually improve aspects of the management of the property, including in relation to ensuring connectivity within the property, and in its wider landscape, and to also secure enhanced community engagement[11].

[11] https://whc.unesco.org/en/list/33/

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Past and current land-use trends

The peripheral location along the eastern border of the country and the EU, the legacy of many years of underinvestment and the unstable political situation in eastern Europe cause development difficulties and exacerbate the area's socio-economic problems.

The Białowieża Forest region is one of the areas with the highest intensity of demographic challenges in Poland. There are coexisting processes of population ageing, emigration and general population decline. At the end of 2023, 38.8 thousand people lived in the Hajnówka county, i.e., 3.4% of the total population of the Podlaskie Voivodeship (1,138.2 thousand). This means that the population decreased by 14.5% over the past 10 years (in 2013, there were 45.4 thousand residents). The average population density of the Hajnówka district was 23.9 people per 1 km² (compared to 28 people in 2013), making it one of the lowest in the country[12].

Analyzing the population structure according to economic age groups, it can be noticed that in the Hajnówka county in the years 2011–2021, the share of people of working age in the total population of the county inhabitants decreased successively, and the percentage of people of post-working age increased. In 2021, the percentage of the population of working age (women aged 18-59, men aged 18-64) was 54.7% and decreased by 5.8 percentage points compared to 10 years earlier. The share of the population of post-working age (women - 60 years and more, men - 65 years and more) in the total population amounted to 30.3% and increased by 5.5 percentage points in relation to the situation in 2011 (IOŚ-PIB 2022[13]). Demographic projections indicate a population decline by 2030, with a decrease of 7% (approximately 2.73 thousand people) compared to 2023 (BDL, 2023[14]).

At the end of 2022, the share of legally protected areas in the total area of the Hajnówka district was 57.4%, including the national park, which accounted for 6.5% of the district's area (compared to 4.6% in the Podlaskie Voivodeship). The area of legally protected areas increased by 2.4% compared to the end of 2011 (when it was 58.8%). In the case of Białowieża National Park (on the Polish side), its area has remained unchanged over the past 10 years, and at the end of 2022, it covered 10,517.3 hectares. Strict protection was applied to 57.6% of the park's total area (Statistical Office in Białystok, 2023).

At the end of 2022, forests in the Hajnówka district covered an area of 87,355 hectares, accounting for 13.8% of the forested area of the Podlaskie Voivodeship (Table 11). Their area increased by 1.3% compared to 2011. In 2022, the forest cover ratio for the Hajnówka district was 53.8%, representing an increase of 0.7% compared to 2011 (Statistical Office in Białystok, 2012; 2023).

In regard to the conditions for agricultural development, they are difficult, consisting of a harsh climate (long and cold winters, short growing season, low levels of precipitation) and low fertility of soils (dominated by low-quality soil classes). Permanent grasslands (meadows and pastures) have a large share in the structure of agricultural land use. The area is characterized by a fragmented agrarian structure - farms of 1-5 ha predominate. The number of households with income from farming is steadily decreasing. The future may lie in the development of organic farming, herbalism and beekeeping (Overregional Strategy, 2023). They can contribute to building a recognizable brand for the region.

[12] BDL, https://bdl.stat.gov.pl/bdl/dane

[13] https://ios.edu.pl/wp-content/uploads/2022/12/bf-ekspertyza-ekspertyza-z-zakresu-lokalnego-rynku-pracy-w-rejonie-obiektu-sw.pdf

[14] https://bdl.stat.gov.pl/bdl/dane/teryt

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Table 11 Area of forest land in Hajnówka district in 2011-2023

Specification	Years								
	2011	**2013**	**2015**	**2017**	**2019**	**2020**	**2021**	**2022**	**2023**
Forest land grand total [ha]	**87 832.4**	**88 062.50**	**88 139.05**	**88 441.11**	**88 564.86**	**88 679.53**	**88 868.79**	**88 851.75**	**88 840.01**
public	76 407.1	76 413.82	76 279.74	76 477.09	76 521.95	76 583.51	76 613.27	76 645.88	76 689.35
privete	11 425.3	11 648.68	11 859.31	11 964.02	12 042.91	12 096.02	12 255.52	12 205.87	12 150.66
Forests [ha]	**86 236.4**	**86 471.83**	**86 552.36**	**86 819.48**	**86 926.92**	**87 042.21**	**87 231.83**	**87 354.93**	**87 380.62**
public	74 811.1	74 823.15	74 693.05	74 855.46	74 884.01	74 946.19	74 976.31	75 149.06	75 229.96
privete	11 425.3	11 648.68	11 859.31	11 964.02	12 042.91	12 096.02	12 255.52	12 205.87	12 150.66
Forest area per capita [ha]	185.1	190.4	194.2	198.5	204.0	214.0	218.0	221.6	225.1
Forest cover [%]	53,.	53.3	53.3	53.5	53.5	53.6	53.7	53.8	53.8

Source: Local Data Bank, https://bdl.stat.gov.pl/bdl/dane/teryt/tablica.

Tourism development also holds great potential, despite the recent decline in tourist activity due to the crisis on the Polish-Belarusian border. In 2020, the Białowieża National Park (BNP) was visited by 158,000 tourists, while in 2022, the number was around 97,000. The Białowieża Forest, as a site protecting Europe's and the world's forest heritage, represents a unique natural potential that allows for the creation of diverse tourism products, particularly in the area of sustainable tourism (Kiryluk, 2016).

What are the most pressing and relevant issues related to land use and land use decisions in your case study area?

According to the protection plan for the Białowieza National Park (REGULATION, MINISTER OF ENVIRONMENT of 7 November 2014) the most important actions concern:

1. Maintenance in a proper state of conservation of natural habitats and species habitats is important for ensuring the integrity of the Natura 2000 PLC 200004 area and the coherence of the Natura 2000 network.
2. Maintain the natural dynamics of the groundwater table location.
3. Take into account the spatial conditions and the conditions of preserving the proper status of the objects of protection in the studies of conditions and spatial management of communes, local spatial management plans and management plans of Podlaskie Voivodeship.
4. Popularise knowledge on natural habitats and species and habitats which are the object of protection of Natura 2000 area.
5. Actions for the establishment and maintenance of ecological corridors enabling the migration of species within the area.

The following conservation activities will also be carried out consisting of:

1. Maintenance of at least one patch of the habitat - floristically rich mountain and lowland semiarid grasslands (Nardion - floristically rich patches), including the sub-type occurring in the Park area: lowland semiarid grasslands of the order Nardetalia of at least 0.05 ha in selected areas of the Park.
2. Incrementation to 14,2 ha of the area of well-developed communities - fresh meadows from the Arrhenatherion elatioris association in selected areas of the Park.
3. Formation of a mosaic of species-rich communities - lowland and mountain fresh extensively used meadows (Arrhenatherion elatioris) of at least 30 ha, with at least 0.02 ha patch of community -

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floristically rich mountain and lowland tall herb fringe communities (Nardion - floristically rich grasslands), including the sub-type occurring in the Park area: lowland tall herb fringe communities of the order Nardetalia in selected areas of the Park.

Castro Verde Biosphere Reserve (BR), Portugal

Partner responsible for the case study:
Centre for Functional Ecology (CFE) of University of Coimbra

Geographical location of the case study

Castro Verde Biosphere Reserve (BR) is in southern Portugal (37°43'N, 7°57'W), in Alentejo region, and have its place in the long and extensive plains of the Beja district. Castro Verde Biosphere Reserve integrates the entire geographical area of the municipality of Castro Verde (567,2 km^2) and is bounded by the municipalities of Beja, Aljustrel, Almodôvar, Mértola and Ourique (Fig. 23).

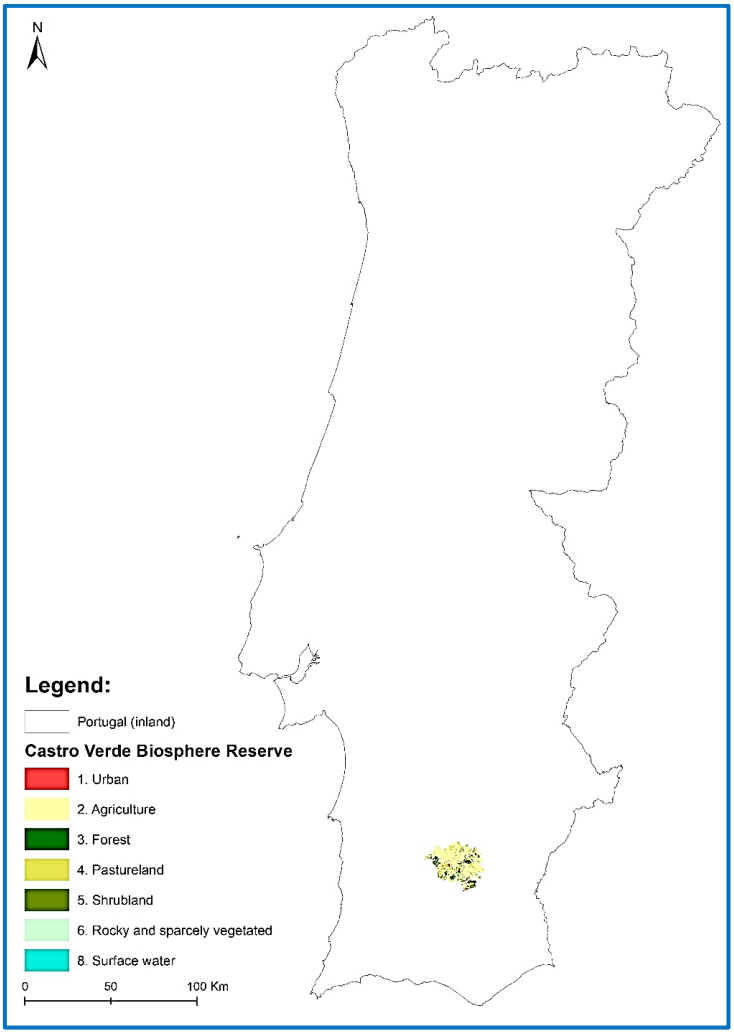

Fig. 23 The position and land uses of Castro Verde Biosphere Reserve in Portugal

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The landscape strongly features arable dry-cereal crops in rotation with fallow land and vast grasslands with livestock, permanently populated with steppic birds, being part of the traditional and historical image of the Southern Alentejo region in Portugal (Fig. 24).

Fig. 24 The lansdcape of Castro Verde Biosphere Reserve - dry-cereal crops in rotation (at top right), open grasslands (at top left and center) and fallow lands typicaly populated by steppic birds such as the lesser kestrel (*Falco naumanni*) (down at left) or the great bustard (*Otis tarda*) (down at right). Pictures retrieved from www.reservasdabiosfera.pt.

Short description of the case-study/Context

The Castro Verde Biosphere Reserve covers an area of 567,2 km2 in inland south Portugal. An important sector in this territory is the mining industry, which provides job opportunities and stimulates the local economy, namely the Neves-Corvo mine. Additionally, the agricultural and livestock sectors play an essential role in the livelihoods of the local population and in the cultural and environmental characteristics of the region. The vast plains with cereal crops and grasslands are the main landscape feature and are often referred to as cereal steppes. This is an agro-ecosystem constituted by arable dry-cereal crops in rotation with fallow land. This spatial-temporal landscape mosaic, perfectly adapted to the ecological features of the territory and the human activities that take place in it, is the result of a millennial relationship between Humans and Nature. However, the Cereal Steppes of Castro Verde represent one of the most endangered rural landscapes in the Mediterranean region. This vulnerability is attributed both to ecological issues (such as the soil's limited productivity)

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and economic factors, including the shift towards higher-yielding crops. Additionally, this landscape supports high levels of biodiversity, including refuges for many steppic birds with unfavourable conservation status, such as the great bustard (Otis tarda), the little bustard (Tetrax tetrax), and the lesser kestrel (Falco naumanni). It is crucial to understand and manage the conflict between the preservation of biodiversity habitat requirements and the safeguarding of soil productivity. Therefore, this case study will be focused on understanding the influence of agri-environmental measures on agricultural production and biodiversity in the Castro Verde Biosphere Reserve. For that, we intend to analyse historical data, including the 30 years of implementation of the first Zonal Plan in Portugal and the years before its implementation in 1995. This will be done by constructing a geodatabase of the land uses over the last 30 years based on remote sensing images (Landsat and Sentinel), land cover maps, and field parcel information, which will be analysed together with the available information on yield, management actions, and biodiversity assessments. Afterwards, we will estimate the past, current, and future provision of ecosystem services and biodiversity under different scenarios of land use and management and climate change.

Land use pattern

The Castro Verde Biosphere Reserve is home to an estimated population of 6900 residents (National Census of 2021). The Castro Verde lansdcape corresponds largely to Cereal crops and Pasturelands as the main occupation (86%) (Fig. 25). Structurally, the Cereal Steppe is characterised as an open mosaic landscape, primarily consisting of cereal fields, stubble, ploughed land, grasslands and fallow areas, following a rotational scheme. In this prevalent rotation system, each farm is divided into individual plots, with each plot dedicated to cereal cultivation for one or two years, after which land is left fallow for a period of 2–3 years. Fallow land is predominantly used for sheep grazing, with goats and beef cattle also using it to a lesser extent. After this period, the plot is plowed, initiating a new rotation cycle.

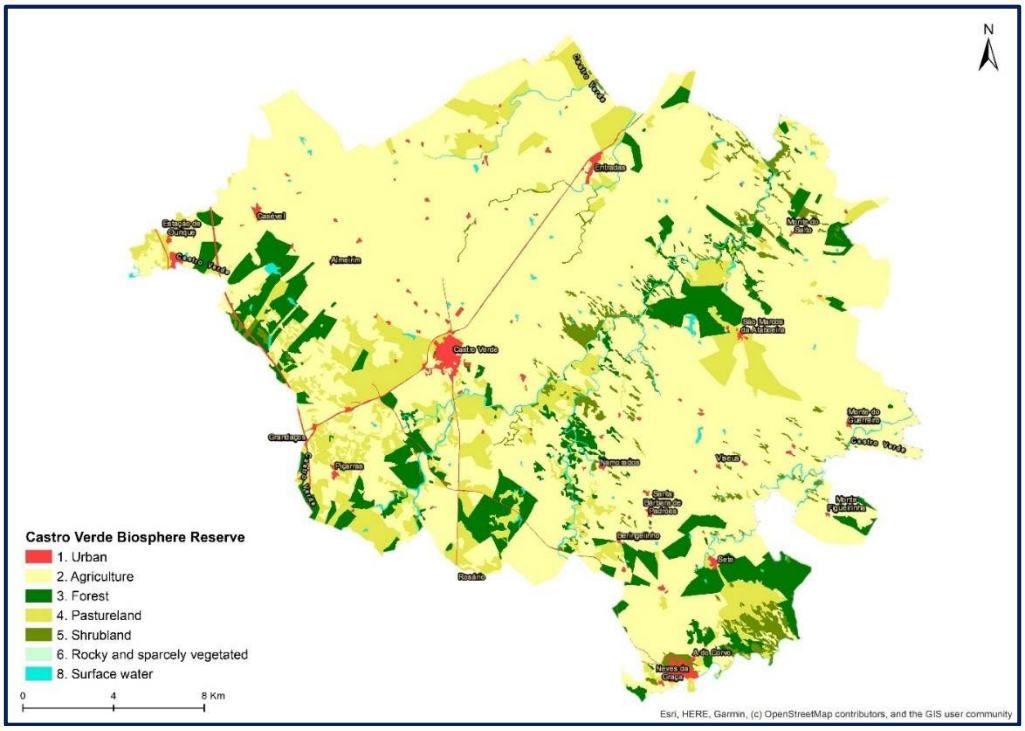

Fig. 25 Castro Verde Biosphere Reserve main land-cover occupation

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Within the mosaic of agricultural fields, there are small areas of dryland permanent crops (typical of Mediterranean areas), including olive groves and vineyards, as well as subsistence agricultural crops. Olive groves are associated with extensive farming and grazing practices, where sub-cover is used as natural pasture (mainly for sheep) and for olive oil production (one of the basic products of the Mediterranean diet). There are also some areas of forest systems with recent pure or mixed plantations of stone pine (Pinus pinea) and holm oak (Quercus rotundifolia).

Another distinctive ecosystem is the Mediterranean scrubland, typically found in rocky outcrop areas that are unsuitable for ploughing or in slightly rugged terrain along streams. Here, the rockrose (Cistus ladanifer) dominates, forming rockrose thickets known as 'Estevais,' which are occasionally accompanied by other rockrose species like Cistus crispus and Sage-leaved Rockrose (Cistus salvifolius), as well as aromatic plants from the Lavandula genus.

The Castro Verde Biosphere Reserve hosts 4 listed Habitats from Habitats Directive with high relevance in the region. For isntance, along watercourses there are well-preserved riparian galleries can be observed, characterised by native shrubs such as Oleander, Tamarisk, and Flueggea tinctoria (which corresponds to habitat 92D0 - Southern riparian galleries and thickets [Nerio-Tamaricetea and Securinegion tinctoriae] - of the EU Habitats Directive). These galleries also have trees like Ash (Fraxinus angustifolia), Poplar (Populus spp.), and Willow (Salix spp.). Furthermore, two out of the four habitats are priority habitats listed under the Directive's Annex I, namely the 6220 - Pseudo-steppe with grasses and annuals of the Thero-Brachypodietea, and the 3170 - Mediterranean temporary ponds. Throughout the territory, there are small dams, reservoirs, and artificial bodies of water, which play a vital role in supporting agricultural activities, supplying water to livestock during the summer, and providing habitat for local wildlife.

Land management

Castro Verde territory is essential for preserving biodiversity and promoting sustainable management practices. Several technical, scientific, and educational projects have contributed to the valuation, conservation, and management of the natural heritage of the region. The involvement of farmers, environmentalists, and public and private entities in these collective interest projects has allowed the recognition and adoption of sustainable practises that maximise the conservation of steppe birds compatible with human activities in the long-term.

The key protected areas at Castro Verde include Special Protection Areas (SPA), Important Bird Areas (IBA), Special Areas for Conservation (SAC) and the UNESCO Biosphere Reserve classification. Castro Verde Special Protection Areas (Piçarras - PTZPE0058 and Castro Verde - PTZPE0046), designated under the European Union's Birds Directive (under the Natura 2000 Network) correspond to 85% of the entire study area, being of critical importance for the conservation of steppe birds with unfavourable conservation status, providing crucial habitat for breeding and foraging. The significance of this area was also recognised by Birdlife International (PT029), which classified the SPA Castro Verde territories as crucial for the conservation of bird populations and the habitats that sustain them on a global scale. The southern part of Castro Verde is also included in the Rio Guadiana SAC. In 2017, this territory has been designated as a UNESCO Biosphere Reserve, a classification that underscores the region's commitment to balancing conservation with sustainable land use and development. Therefore, Castro Verde has been a pilot area to test tools, methods, and techniques to combat desertification and to promote climate change adaptation and mitigation of negative impacts on steppe biodiversity. As a result, the Biosphere Reserve works like a "living laboratory", promoting the implementation of environmental policies at the local and regional levels, such as the National Strategy for Nature Conservation and Biodiversity ("Estratégia Nacional da Conservação da Natureza e da Biodiversidade", ENCNB) and the National Strategy for Adaptation to Climate Change ("Estratégia Nacional de

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Adaptação às Alterações Climáticas", ENAAC 2020). In addition, the National Action Plan to Combat Desertification ("Plano de Ação Nacional de Combate à Desertificação", PANCD 2014-2020) indicates Castro Verde as a critical territory for national environmental networks to work together and promote soil recovery and conservation actions. Furthermore, LPN, national authorities (e.g., Institute for Nature Conservation and Forests, ICNF), academic institutions, and other non-governmental organisations have been monitoring wildlife populations, like the great bustard, the little bustard, the lesser kestrel, the roller (Coracias garrulus), the black-bellied sandgrouse (Pterocles orientalis), the red kite (Milvus milvus), the Montagu's harrier (Circus pygargus), the Iberian imperial eagle (Aquila adalberti) and the common crane (Grus grus).

Additionally, within farming and livestock activity, sustainable agricultural practises have been implemented to minimise the impact of agriculture on the environment and combat desertification. These collaborative efforts, which involve entities such as the Campo Branco Farmers Association (AACB), LPN, and public and private institutions, have played an important role in the promotion of sustainable development of Castro Verde.

In short, the Castro Verde Biosphere Reserve aims to support the management policy of the whole territory, following the guidelines and directives of different international, national, local and regional authorities:

- The Alentejo Regional Land Management Plan ("Plano Regional de Ordenamento do Território do Alentejo", PROTA, approved in the Resolution of Council of Ministers No. 53/2010 of 2 August, with changes made by the Declaration of Rectification No. 30-A/2010 of 1 October);
- The Municipal Master Plan of Castro Verde ("Plano Diretor Municipal",PDM, approved by Resolution of the Council of Ministers No. 59/93 of 13 October, with changes approved by Resolution No. 2271/2010, of December 7) – the PDM is currently under development.
- The Natura 2000 Sectoral Plan ("Plano Setorial da Rede Natura 2000", PSRN 2000, approved by Resolution of the Council of Ministers No. 115-A/2008 of 21 July)
- The Legal Framework for Nature Conservation and Biodiversity ("Regime Jurídico da Conservação da Natureza e da Biodiversidade", Decree-Law No. 242/2015 October 15)
- The National Strategy for Nature Conservation and Biodiversity ("Estratégia Nacional da Conservação da Natureza e da Biodiversidade", ENCNB)
- The European Union Biodiversity Strategy for 2020;
- The National Action Program to Combat Desertification ("Programa de Ação Nacional de Combate à Desertificação", 2014-2020);
- The Tourism Strategy for the period 2017-2027 (ET 27).

Past and current land-use trends

The vast area of Castro Verde's Cereal Steppe can be mainly attributed to the "Wheat Campaign," which was an economic and political initiative aimed at achieving self-sufficiency in wheat production within the country. This agricultural rush, known as the Wheat Campaign, unfolded during the 1930s and resulted in the clearing of existing vegetation and trees. It involved the ploughing of various types of soil on different slopes, leading to widespread soil erosion. Consequently, soil productivity sharply declined, prompting a transition from an intensive cereal cultivation system to an extensive mixed system characterised by both cereal and livestock farming.

In the 1980s, this region started being threatened by afforestation with eucalyptus. To safeguard against this, by the beginning of the 1990s, the Municipality of Castro Verde banned the plantation of fast-growing forest trees in approximately 85% of its area (approved by PDM). This aimed to prevent agricultural abandonment and depopulation. Additionally, the LPN (League for the Protection of

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Nature) launched a highly successful awareness campaign supporting the preservation of this landscape and the conservation of the Great Bustard.

In 1995, a management program for this landscape, known as the Zonal Programme of Castro Verde (ZPCV), was implemented as part of the EU Agri-environmental measures. This programme aimed to prevent the loss of suitable habitat for bird species with unfavourable conservation statuses. This was achieved by providing financial incentives to farmers who kept their land with the traditional dry-cereal and grasslands rotation. In addition, farmers were obliged to adapt certain practises according to the life cycles of bird species. However, despite the Zonal Program of Castro Verde efforts (which introduced the rotation system with the aim of preserving soil integrity and enhancing soil fertility), it did not prevent the continuing erosion of the very thin and shallow soils brought into cereal cultivation. To face this challenge, LPN initiated demonstration projects at its farms. These projects were designed to enhance soil quality and root depth effectively. They employed methods such as subsoiling, the injection of wastewater sludge, and the implementation of direct seeding techniques.

Today, the Castro Verde Biosphere Reserve maintains a predominantly rural character, characterised by extensive open areas dedicated to cereal cultivation and pastures. The soils, primarily derived from schist, are characterised by their thinness and inadequate drainage. The few patches of shrubland and "montado" (Holm Oak woodlands) are scattered and located only in the buffer and transition areas, representing remnants of the degraded original vegetation cover. Throughout the evolution of soil use and land occupation, numerous mammals, reptiles, amphibians, insects, and especially birds have adapted to the changing landscape. They are now reliant on human activity and the management of these cereal steppes for their survival.

What are the most pressing and relevant issues related to land use and land use decisions in your case study area?

The main objectives outlined by the managers of the Castro Verde Biosphere Reserve highlight the most pressing and relevant concerns related to land use and decision-making. The key actions to address these concerns include:

•Conservation of Castro Verde Cereal Steppe: This is of the utmost importance to support habitats and biodiversity, particularly for steppe birds. Hence, it is imperative to enhance agricultural and livestock practices, as this not only secures the preservation of the traditional landscape but also safeguards the species dependent on it, many of which are in threatened status. This approach aims to adopt a green economy;

•Preservation of Landscape and Natural Resources: The focus here is on maintaining the environmental quality of the landscape and its ecosystem services, such as water and soil regulation. It involves the promotion and adoption of best practises that guarantee the sustainability of economic activities, particularly low-intensity, low-input agriculture;

•Integrating Conservation and Cultural Preservation with Innovation and Technology: Investing in innovation and technology (IT) has the potential to foster the establishment and growth of enterprises specialising in natural-based solutions, thus bolstering the sustainable development of the region and its residents (and eventually attracting new residents). Moreover, IT could enhance the efficient utilisation of ecosystem services, such as deriving wool from livestock or leveraging landscapes and culture for the tourism sector. This, in turn, could reduce waste, add value to products, and generate a greater number of employment opportunities. This approach aims to create opportunities for economic activities, improve the quality of life for the local population, and enhance social equity;

•Improvements on the Promotion of Knowledge Exchange: Encouraging the production and exchange of scientific, technological, and traditional knowledge is vital to the efficient conservation of

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ecosystems and biodiversity. This involves collaboration between the scientific community, political decision-makers, and citizen groups;

•Environmental Education: Encouraging environmental education is of utmost importance in raising awareness and fostering an understanding of conservation matters. Furthermore, it should serve to underscore the significance of Castro Verde's Biosphere Reserve (a UNESCO designation) among both local residents and visitors;

•Promotion of Sustainable Tourism: The goal is to promote tourism activities that align with the natural and cultural values of the area, with the added benefit that tourism should also contribute to the local economy and farmers (who are essential to guaranteeing these landscapes and the natural and cultural value of this region).

Braila Islands, Romania

Partner responsible for the case study: Romanian Academy, Institute of Geography

Geographical location of the case-study

Brăila Islands are located in the south-eastern part of Romania, in the Danube Floodplain, between the main branches of Danube River (Cremenea and Măcin) (Fig. 26). The study area covers about 97,000 hectares and includes two distinct areas: a predominantly agricultural area, the Big Brăila Island (over 71000 hectares) and a wetland protected area, Balta Mică a Brăilei (Small Brăila Island) natural park (24 100 hectares) (Fig. 27). In order to provide a good overview of the farming system in the region, the case study will be extended for the entire county of Braila (as an administrative unit).

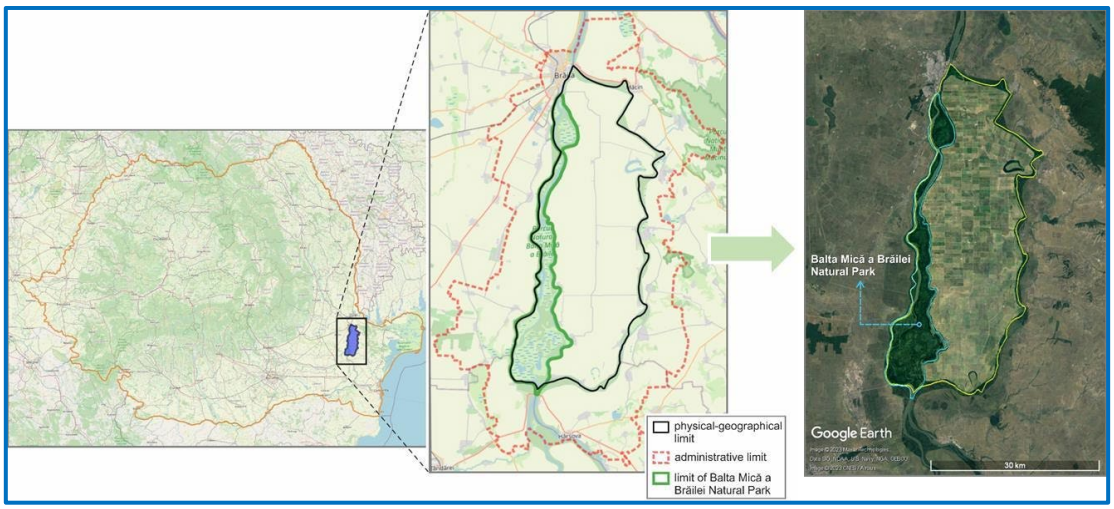

Fig. 26 Geographical position of Braila Islands

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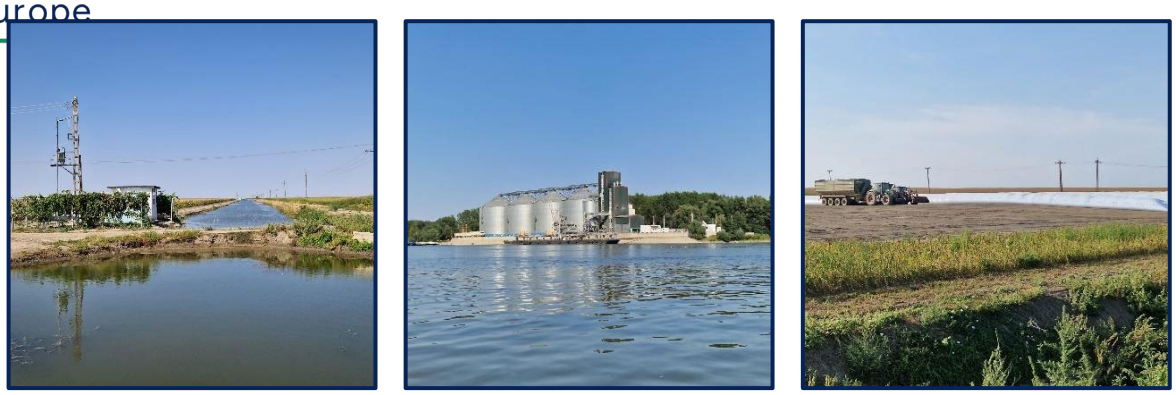

Fig. 27 Main landscape features of the region

Short description of the case-study/Context

The Big Brăila Island. Until the second half of the 20th century, the Big Brăila Island landscape was characterized by numerous ecosystems: aquatic ecosystems (ponds, lakes, marshes, sloughs, streams and canals) and terrestrial ecosystems (forests, grasslands, farmlands). The changes in the land use/cover pattern were mainly due to the influence of the hydrological regime of the Danube River and very little of the anthropic factor. Human activity was dependent on the characteristics of environmental factors. The settlements were built on terraces or on the high ground, protected from floods. The main population activities were animal husbandry, fish farming and hunting.

During the communist period, the complex hydrotechnical and agro-improvement works (damming, drainage-dredging and irrigation) took place that transformed wetlands into agricultural land, the latter covering over 94% of the total area.

The area totally covers two communes (Mărașu, Frecăței) with a total population of 3,767 inhabitants (2023). Agriculture is the main economic activity and the main crops cultivated in this area are cereals, fodder plants and sunflower.

Balta Mică a Brăilei Natural Park is situated in the western part of Brăila Island and it is a Wetland of International Importance included on the RAMSAR list (since June 2001) and since 2008 has received the status of Natura 2000 Site (as a Site of Community Importance and as a Special Area of Avifauna Protection). The landscape is dominated by wetlands (lakes, inland marches, water bodies) and forest ecosystems (Fig. 27).

The area is divided into four different zones, according to the management plan[15]: the strictly protected area (418 ha); the total protected area (5,741 ha); the management (buffer) area (9,028 ha); the sustainable development area (8,891 ha). The main activities are tourism (eco-tourism, agro-tourism, scientific tourism), navigation (on Danube River), recreational/ sports fishing and pastoral activities. The territory of the natural park partially overlaps the surface of five communes: Bertestii de Jos, Stăncuţa, Gropeni, Tichilesti and Chişcani.

Land use pattern

In Brăila Islands, in 2018 (according to CLC 2018), arable land represented the main land use category with 70,379 ha (72% of total surface area); followed by forests 13,704 ha (14%); inland marches 6,145

[15] https://bmb.ro/wp-content/uploads/2019/11/plan-management-bmb.pdf

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ha (6.3%); water bodies 5,609 ha (5.7%); built-up areas 1,001 ha (1%) and natural grasslands and pastures 866 ha (0.9%) (Fig. 28).

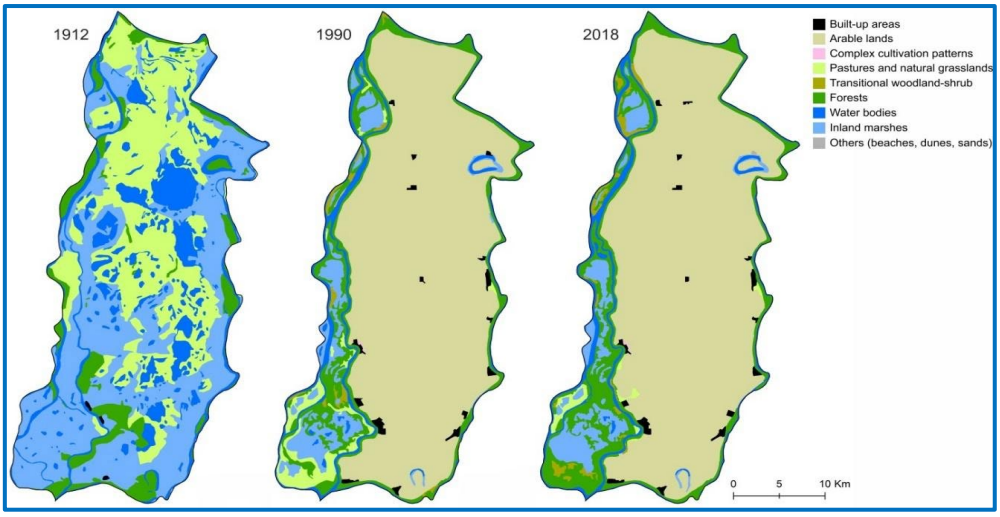

Fig. 28 Dynamics of land use/cover pattern 1912, 1990 and 2018

General characteristics of agricultural farms. The largest agricultural farm in Europe (56,000 ha) is located in Big Brăila Island, where an intensive agriculture is practiced, with high yield/ha (up to 10,000 kg/ha for maize, 6,500 kg/ha for wheat), far above the national average production.

According to CORINE Land Cover 2018, in Brăila county the predominant LU/LC classes are: arable lands (357,981 ha, 75% of total surface area); pastures and natural grasslands (32,522 ha, 6.8%); forests (23,370 ha, 4.9%); built-up areas (21,227 ha; 4.5%) and water bodies (12,457 ha, 2.6%).

After 1989, Land Law 18/1991 came into effect, landed property would crumble excessively, thus large farms growing into peasant-type family exploitations. In 2020 there were 29,576 agricultural holdings (2020) using over 382,995 hectares of agricultural land (National Institute of Statistics). Average agricultural area/farm was 12.9 ha, above the national average of only 2.73 ha. Regarding the spatial size of farms, in Brăila County two categories can be clearly distinguished within the farm size class. The first category includes very small and small farms of less than 5 hectares, which represent 81% of the total number of farms (2020) and possess about 6.4% of the total agricultural area used (Fig. 29, Fig. 30). It should be remembered that 52% of farms in this category have below one hectare, therefore they are not eligible for receiving direct payment/hectare.

The second category consists of large and very large farms of over 100 ha, or 1,000 ha even (the largest agricultural farm in Europe has over 56,000 hectares and is located in the Big Brăila Island). They possess 71.2% of the total agricultural area, but represent only 2% of all farms (2010).

In-between these two categories stand the medium-sized farms (5-10 ha, 10-50 ha and 50-100 ha), basically family associations, producing for the market or some of them for self-consumption. Although these farms should be dominant, yet they represent only 17.2% of the total number of farms and possess 22.4% of the total agricultural area used.

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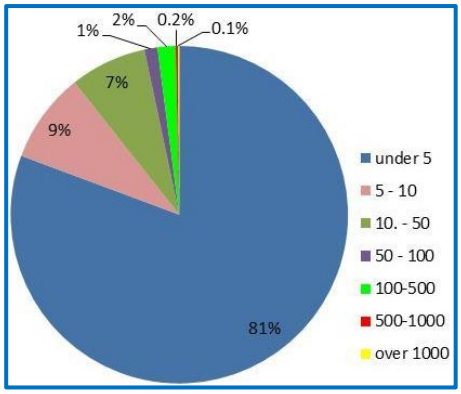

Fig. 29 Number of agricultural farms
By size classes (%) in Brăila county

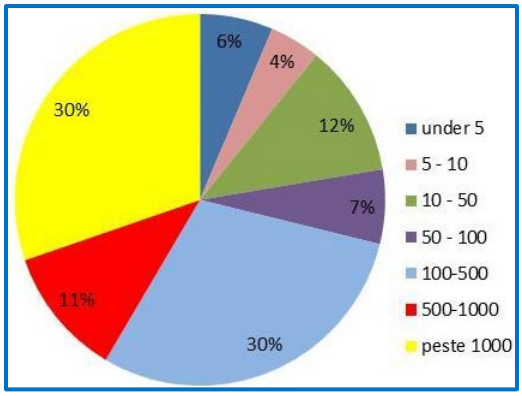

Fig. 30 Agricultural farms by size classes of
utilised agricultural area (%) in Brăila county

Concerning the type of tenure of utilised agricultural area, the agricultural area owned by agricultural exploitations represents more than 24% of the total agricultural area used, followed by leasing with 42.5%, while the other types of tenure represent only 33.5% (2022).

Land management

There is no available up-to-date information on specific management practices targeting the case study, and fieldwork and contact with relevant stakeholders have been done to obtain this information. However, in the Brăila Islands, during the communist period over 69,000 hectares of agricultural lands were equipped with irrigation facilities. In 2023, as mentioned in a newspaper by the manager of the farm, in the largest agricultural farm in Europe, of the 56,000 hectares, 57,000 were irrigated with 640 pivot type irrigation installations[16].

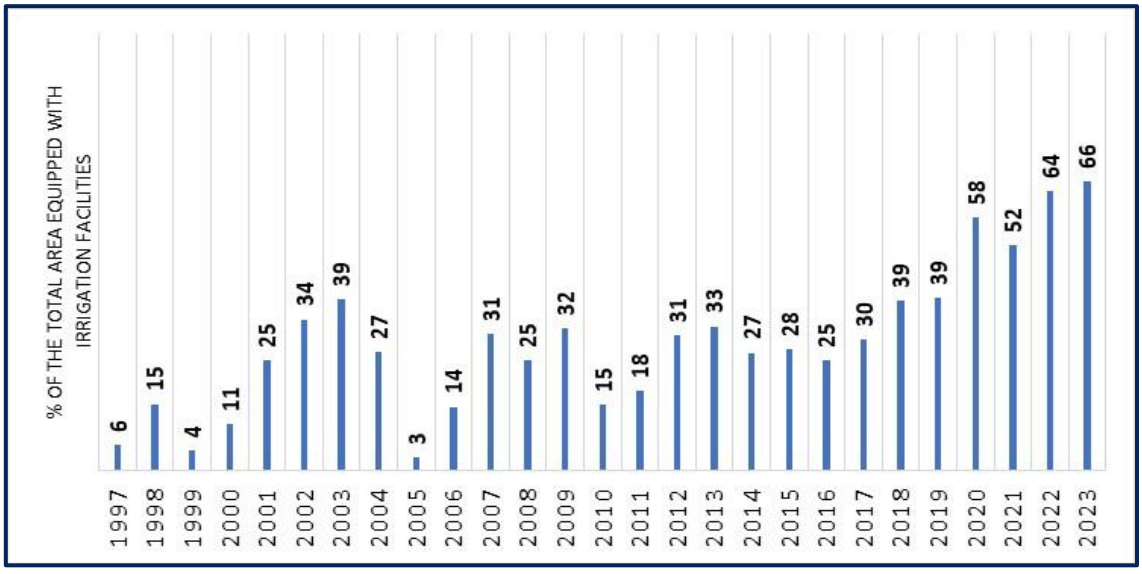

Fig. 31 Share of the irrigated agricultural area in Brăila county (% of the total area equipped with irrigation facilities) Source: National Institute of Statistics

[16] https://foodbiz.ro/2023/12/20/braila-este-cel-mai-irigat-judet-din-romania/

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Among the 41 counties of Romania, Braila County has the largest irrigated agricultural areas. In 2023, 235,832 ha of agricultural lands were irrigated, which represents over 66% of the agricultural area equipped with irrigation facilities in Braila County and almost 50% of the irrigated agricultural area at the country level (Fig. 31). The rest of the agricultural lands left unirrigated is usually owned by small farms that, in the absence of state support, don`t have sufficient financial resources to support the irrigation costs.

Past and current land-use trends

Brăila Islands. The significant long-term changes of land use and land cover in the Danube Floodplain are the result of political and socio-economic evolutions, as well as of biophysical and climatic drivers. The direction and amplitude of land-use change are distinctively different, depending on the political and economic conditions of each period. The first human interventions in the Danube Floodplain were registered at the beginning of the 20th century, but the most extensive land improvement works took place during the communist period when the Danube Floodplain was fully dammed (over 1,000 km of dams), works having started in 1960 and ended in 1966. It was the beginning of the human impact on the landscape and functioning of the complex ecosystems in the floodable Danube region. By the end of the communist period, 75% (431,760 ha) of the Danube Floodplain area (573,000 ha) in natural regime had been dammed, complex water management works consisting in 1,158 km of impoundments, 418,000 ha drained and dredged, 225,000 ha irrigated (Vişinescu and Bularda, 2008) (Fig. 32). The purpose of drainage-dredging works was to enlarge the agricultural area, fact that entailed an important shift in the land-use and land-cover structure.

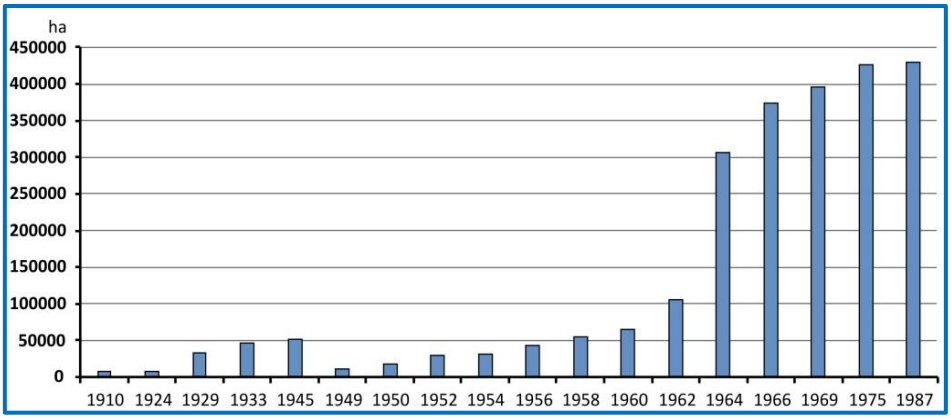

Fig. 32 Dynamics of dammed surfaces in the Danube Floodplain
Source: Vișinescu and Bularda, 2008

In Brăila Islands, the complex hydrotechnical and agro-improvement works (damming, drainage-dredging and irrigation) started in 1949 and were carried out in several stages. In the first stage, damming works were carried out on the entire surface (approximately 71,994 ha) which ended in 1964, followed by drainage and dredging works that lasted until 1985, at the same time works were made for irrigation on an area of over 69,000 hectares. In the western part of the Brăila Island there is a small area of about 24,000 ha (Balta Mică a Brăilei Natural Park) that represents the only floodplain area along the lower Danube valley subject to the natural flood regime (Toader 2005). In the communist period, the land use/cover pattern experienced drastic changes due to these vast damming, draining and irrigations works that had also significantly affected the lakes and wetlands, soil quality, the topoclimate and hydrological regime of the Danube and of ground waters. So, this period represents an important stage in the dynamics of land use and land cover pattern through the increase of agricultural land to the detriment of wetlands and water-covered areas.

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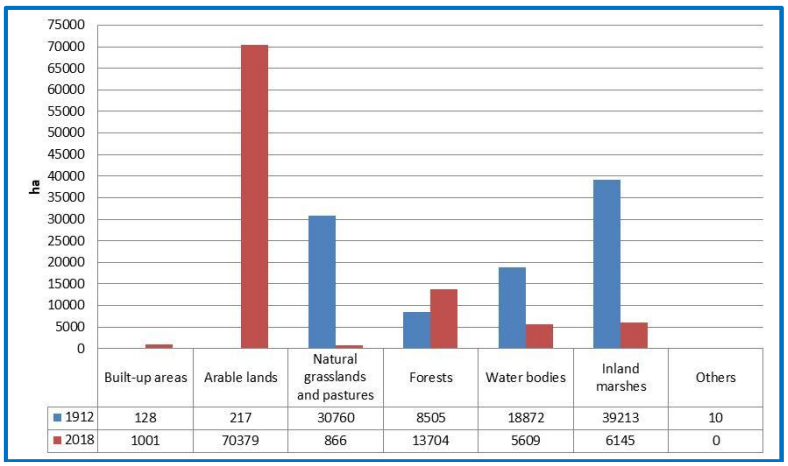
According to the Austrian map of 1912, before the Brăila Island was fully dammed, the main land use cover categories were: inland marshes 39,213 ha (40% of total study area); natural grasslands and pastures 30,760 ha (31.5%); water bodies 18,872 ha (19.3%); forests 8,505 ha (8.7%) and built-up area 128 ha (0.1%) (Fig. 33).

In 2018 (CLC 2018) arable land represented the main land use category with 70,379 ha (72% of total surface area); followed by forests 13,704 ha (14%); inland marches 6,145 ha (6.3%); water bodies 5,609 ha (5.7%); built-up areas 1,001 ha (1%) and natural grasslands and pastures 866 ha (0.9%).



	Built-up areas	Arable lands	Natural grasslands and pastures	Forests	Water bodies	Inland marshes	Others
1912	128	217	30760	8505	18872	39213	10
2018	1001	70379	866	13704	5609	6145	0

Fig. 33 Land use/cover pattern in Brăila Island, 1912 and 2018
Source: CORINE Land Cover 2012, 2018

What are the most pressing and relevant issues related to land use and land use decisions in your case study area?

- Low adaptation potential of small farms and low-income subsidence farms. This category of farmers is very widespread in Romania, as well as in Brăila county, and is likely to be the most affected by climate change, being very dependent on rain-fed agriculture and needing special attention and support in terms of adaptation.
- Irrigation needs. The main climate adaptation measure considered crucial by the farmers is the rehabilitation/construction of irrigation systems.
- Changes in the farming management practices (e.g. choice of more drought-resistant crop varieties, change in crop calendar, rainwater harvesting, use of advanced technology for agricultural works capable of maintaining water in the soil etc.)
- Intensifying the land concentration and land grabbing phenomena with significant socio-economic consequences, such as: marginalization of small-scale farming, the establishment of monocultures and difficult access of young and future farmers to developing agricultural activities.
- The replacement of diversified small and medium-scale family farming, based on friendly environmental practices with an industrial agricultural system which largely depends on monoculture production and the increasing use of synthetic fertilizers and pesticides.
- Needs for insurance of agricultural crops to extreme events-related losses

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LTSER Trnava, Slovakia

Partner responsible for the case study: SUA in Nitra

Geographical location of the case-study

LTSER Trnava[17] is located in the south-west Slovakia, in territory of one city (Trnava) and 22 rural municipalities with total area of 364 km2. The main part of the LTSER (central and southern parts) is located in the Danubian Lowland (Fig. 34). In this part of LTSER is located the largest settlement – Trnava.

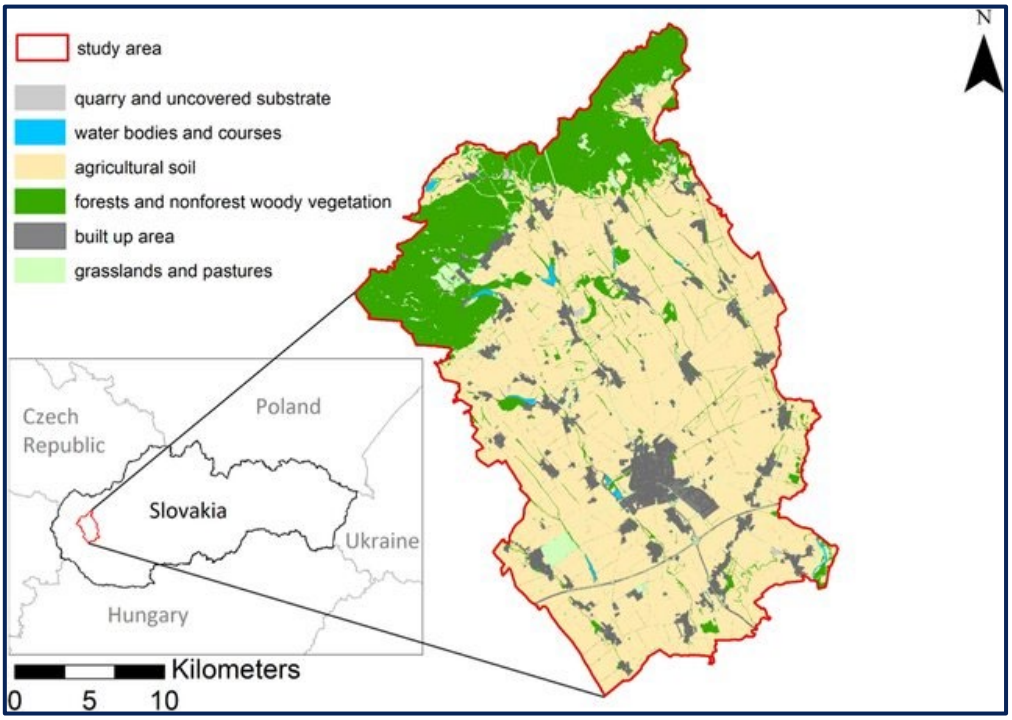

Fig. 34 Current landcover of the study area of Trnava LTSER platform
Source: Izakovičová, Z., et al. Data collection for assessment of the natural capital at the regional level: case study of LTSER Trnava region. Environ Sci Eur 36, 65 (2024). https://doi.org/10.1186/s12302-024-00894-w

Short description of the case-study/Context

LTSER Trnava is located in the south-west Slovakia, in territory of one city (Trnava) and 22 rural municipalities with total area of 364 km2. City Trnava represents the administrative centre of the county and region with highest population, trade and industry. The LTSER represents intensively used industrial and agricultural area with specific environmental problems (strong degree of contamination of environment, the degradation processes of agricultural land, etc.) and low degree of ecological stability. Use of the most productive soils for construction of industrial parks represents a significant environmental issue.

[17] https://deims.org/fabf28c6-8fa1-4a81-aaed-ab985cbc4906

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Land use pattern

Arable land dominates (75.1 %), followed by forests (13.1%), water bodies (0.5%), vineyards, orchards and gardens. Because of the best, most fertile soils and favourable climatic condition, it is intensively used for agriculture, especially as arable land. Hilly northwest part of the LTSER, located in the Little Carpathians Mts. belongs to the Malé Karpaty Protected Landscape Area. This is the only large protected area having vineyard character in Slovakia; vineyards forms transition belt between lowland arable land and forested hills/mountains. Several types of deciduous forests are developed – oak-hornbeam and beech forests are most common, in steeper sites are developed ravine forest dominated by ash and maple. There are several protected areas in the 4th and 5th stages of nature protection: 3 protected areas, 8 nature reserves, 2 national the Nature Reserves. There are also 3 locations of the category natural Monument and 4 Natura 2000 sites. Industry is at the core of the economic base and agriculture. Industrial production is concentrated in the city of Trnava – dominating sectors are Automotive, Engineering and Glass industry. From a national point of view, the county dominates in electricity generation, there is nuclear power in the territory (Jaslovské Bohunice). The economic activity of rural settlements is represented by small production, storage and repair operations. Agricultural production is focused on both crop and livestock production. Crop production is dominated by arable land management. The area in the past was very important in terms of viticulture. In the present period, vine cultivation is significantly receding, which is a nationwide trend. Fruit production is also partially represented and gardening. The area has a smaller share of permanent grassland. Livestock production specialises mainly in the rearing of pigs and cattle, in particular meat and milk. Animal production is also gradually declining due to its complexity.

Land management

Many results of landscape-ecological research formed the basis for the processing of development documents not only for the region, but also for the processing of development documentation of individual municipalities[18] – the territorial and planning documentation of the Trnava Self-governing Region, the Plan of Economic and Social Development of Municipalities. The municipalities of the region have drawn up the development documentation into which they have been also incorporated criteria and principles of sustainability (territorial planning documentation, economic and social development plans, in some cases also land-environmental documents such as the territorial system of protection of ecological stability, regional environmental plans, or local Agendas 21). Various grant schemes of an international or national nature have been set up to implement environmental projects. The Village recovery programme was successfully launched, thanks to which it was implemented several measures aimed at improving the environment in individual municipalities.

[18] Land use government in Slovakia is managed at national level (Ministry for Transport and Construction - lanning processes; Ministry of the Environment - land-use policies), at regional level (preparation and approval of Regional Land Use Plans), at the municipal level (local land-use plans, taxes on land and buildings, social housing and urban regeneration). Major laws and regulations - the Building Act (land-use plans); Environmental Impact Assessment Act (indicative role); Nature and Landscape Protection Act and Act on the Protection of Cultural Monuments.

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Past and current land-use trends

A significant milestone were the transformational changes in society. The biggest changes were recorded in the economic sphere, where it shifted from centrally planned management to a market economy. These conditions have significantly affected not only the structure of the industry, but also the structure of agriculture. There has been a breakdown of many cooperatives, the state farms as well as many other state-owned enterprises. There are currently 11 non-functioning farms in the district, out of a total of 52. There has been a decline in agriculture and a rapid pace of industrial development, which employs up to 40 % of the population of the county, while in 1998 it was almost 10 % less (30.9 %). Only 3 % of the population remained in agriculture, compared with 11.3 % of the population in 1998.

The land is mostly managed by private entities renting land from the original owners. This has led to a significant weakening of the economic base of many rural settlements of the district. Job opportunities have been lost, unemployment of the low-skilled agricultural labour force has increased. From an economic and social point of view, the construction of PSA Peugeot Citroën Slovakia's automotive operation and several electrotechnical operations was a significant contribution. The construction of industrial sites has been positively reflected in the reduction of unemployment and other economic indicators have also improved (between 2008 and 2014, 140 new industrial sites were established).

Structural changes are associated with negative impacts, in the environmental field. New industrial sites were very often built on a "green meadow" and put considerable pressure on having the best quality soils. At the same time, the closure and liquidation of agricultural cooperatives caused an increase in abandoned and unmaintained buildings with negative effects on the structure and aesthetics of the landscape. At present, up to 21 % of agricultural areas are inoperable. The change in agricultural structure has been reflected in the retreat of traditional forms of farming in the country. The development of the agricultural land market has made the highest quality land often sold for the construction of single-family houses, recreational and various other technical facilities. In rural villages, new villa districts and industrial sites often fail to respect the environmental and aesthetic requirements of the rural environment. Immigration of urban populations to rural settlements, largely because of preference for better quality of the environment, has also negative consequences for quality of life in local communities (individualism and isolation, social exclusion, restriction of communication, egoism and "cocooning", preference for one's own local interests, loss interest in public affairs, etc.).

What are the most pressing and relevant issues related to land use and land use decisions in your case study area?

The land is a natural non-renewable resource, a natural heritage and economic, social and ecological potential of each country. Our approach respects the critical importance of social and economic factors influencing changes in land use patterns, including demographic changes, social attitudes, traditions and social norms, individual behaviour, ownership and competing economic sectors seeking to maximise profit opportunities. These components are institutionalised through, inter alia, land-use planning policy, property rights, taxation policy, environmental designations (international, European, national and local) and agri-environmental policy, and are also shaped by competing political or sectoral priorities.

A sustainable land use strategy should be based on a complementary view of land as a relationship between different forms of capital and the values it represents. Therefore, pointing out the most

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pressing and relevant issues related to land use and land use decisions, our understanding (valuing/measuring/analysing) land use and land use decisions will adopt Pierre Bourdieu's theorethical framework on different forms of capital and a three key perspectives on land:

1. as a commodity (economic capital) with a focus on sectoral aspects of land use;
2. as a social value (social and cultural capital), with the aim of understanding the wide range of attitudes and preferences of multiple stakeholders towards land use and land use change, not only in relation to material landscape features, but also to their intangible aspects and in the context of local identity formation;
3. as natural heritage (natural capital) in a broader socio-economic context, emphasising the concept of ecosystem services and the application of ecosystem services in policy and decision-making processes.

The main objective of our methodological approach is to develop a concept for the analysis of land use strategies in Slovak conditions by synthesizing quantitative and qualitative data assessing the potential of land use patterns from different perspectives; and to stress that land use is a complex system with multiple elements and interrelationships, with the methodological starting point being the concept of multidimensional capital, which allows to understand land as a basic resource in terms of economic, social, cultural and natural capital. This interdisciplinary research strategy will allow a more comprehensive understanding of the complexity of land use change and the identification of land use strategies that best contribute to climate change mitigation and adaptation and biodiversity conservation.

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2.5. Stakeholders' mapping in Europe-LAND

The existing literature on LLs emphasizes the presence of multiple stakeholders, who bring heterogeneous resources and knowledge into the co-creation activities (Hossain et al., 2019; Leminen et al., 2020). These stakeholders, belonging to various groups within the Quadruple Helix model, collaborate to address complex challenges through innovation processes. To better understand the dynamics of these collaborations, stakeholder analysis is a crucial process within the stakeholder mapping stage, involving the examination of the diverse interests, roles, and expectations of the stakeholder groups. This analysis facilitates effective collaboration enabling these groups to innovate, test, and develop user-centered solutions in a real-life environment.

The goal of stakeholder analysis is to understand how different stakeholder groups may be affected by a proposed action, identify ways to enhance the positive outcomes, and explore strategies to minimize any potential negative impacts by modifying the proposed action (Babiuch and Farhar, 1994). According to several guidelines (Reed et al., 2009, Durham et al., 2014) stakeholder analysis involves some major steps:

Stakeholders' identification. The *first step* is to identify all relevant stakeholders, i.e., parties who have an interest in the project's activity, or are directly or indirectly affected by the research, as well as those who have the potential to influence the project's results. Stakeholders can be organized into different groups based on the Quadruple Helix model (e.g. civil society organizations, government, private sector, academia).

There are two approaches to identify all relevant stakeholders systematically: 'ex-ante' – identifying them in predefined categories, and 'ad-hoc' – identifying new stakeholders based on recommendations from existing stakeholders. Researchers may follow a 'snowball sampling' approach until no new stakeholders are identified (Durham et al., 2014).

Stakeholders' classification by influence and interest. The *second step* involves the investigation of stakeholder interests. A stakeholder's matrix can be created, ordering stakeholders according to their level of influence and their potential impact on the project. For this assessment, **Reed et al. (2009) provide various tools, including** key informant interviews, focus-groups, surveys, workshop or a brainstorming exercise, depending on the communication method considered most appropriate for each group of stakeholders.

Stakeholders' relationships and interdependencies. The *third step* focuses on analyzing the interrelations among stakeholders. This involves evaluating their needs, worries, desires, authority and relationships. This information is aligned with the stakeholder matrix.

Overall, stakeholders mapping helps prioritize them and visualize their relationships not only towards the intervention, but also with each other. Several visual tools may be used to help map stakeholders in order to represent their power, interest and relations as determined from the previous steps, including interest-influence matrices; 'extendable matrices'- Reed et al., 2009) mind maps etc. Additionally, `rainbow diagram` is recommended (Chevalier and Buckles, 2008) to classify stakeholders according to the degree they can affect or be affected by the research.

In the Europe-LAND project, the structure of the stakeholders corresponds to the Quadruple Helix model, a model suited for promoting knowledge sharing across different institutional and spatial levels through multi-stakeholder collaboration. In the context of the Europe-LAND project, this collaborative

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structure enables a holistic approach to land management, effectively addressing the challenges posed by climate change and biodiversity loss.

A guideline for the stakeholder mapping has been elaborated to ensure uniform scrutiny among countries and case studies and a stakeholder database has been prepared. The database is continuously updated in the project and constitutes the main pool of stakeholders for the planned participatory actions. The stakeholder identification was guided by the following questions:

1. **Who is currently involved in the land management and land use decision at the national, regional and local level (decision-makers), in connection with climate change and biodiversity conservation?** (Note: Local level approach is connected with the case-studies)
2. **Who is influenced by changes in land use, by the legislative decisions related to land management?**
3. **Who are the actors who could help us to better understand the key motivations and drivers behind land-use decisions at various levels in your country?**
4. **Who are the actors who could help us in understanding the barriers to changes in land management as means to adapt to climate change and promote adoption of conservation practices?**
5. **Who are the actors who could be more interested/benefit from our project's results or help us shaping the project's outcomes?**
6. **Who are the actors with interest in influencing a policy related to environmental protection, climate change and biodiversity?**
7. **Who are the best actors to share with the work you perform in Europe-LAND?**

A total of 353 stakeholders, including governments, non-governmental organizations, academia, the private sector, and civil society, were listed by each country involved in the project. A significant percentage of these stakeholders were from Germany 24.1% (85 stakeholders), followed by Slovakia (16.4%, or 58 stakeholders), Romania (13.6%), and Greece (11.9%). Additionally, Latvia, Estonia, and Denmark were represented by less than 4% of the total stakeholders, reflecting the smaller size of these countries. It is important to note that the identification of a significant number of stakeholders from a variety of countries ensures a broad range of experience, perspectives and insights.

To define the different groups of stakeholders, a template was developed focusing on specific criteria such as the geographical coverage (the level of their main area of activity), the primary and secondary categories, their level of importance within the project, and the previous contact. Regarding the level of activity of the 353 stakeholders identified in all partner countries, the majority are active at the national level (42.78%), followed closely by stakeholders involved in local-level activities (41.64%), and a smaller percentage at the regional level (15.58%). The distribution of stakeholder groups across the partner countries is shown in Figure 35. Among the 12 partner countries, Denmark, Greece and Italy identified mostly national-level stakeholders, since there are no case studies at the local level developed by the partners in these countries. Furthermore, Slovakia (75.9%), Germany, and Portugal stand out for listing stakeholders at the local level, while Austria has mainly identified stakeholders at the regional level (62.5%).

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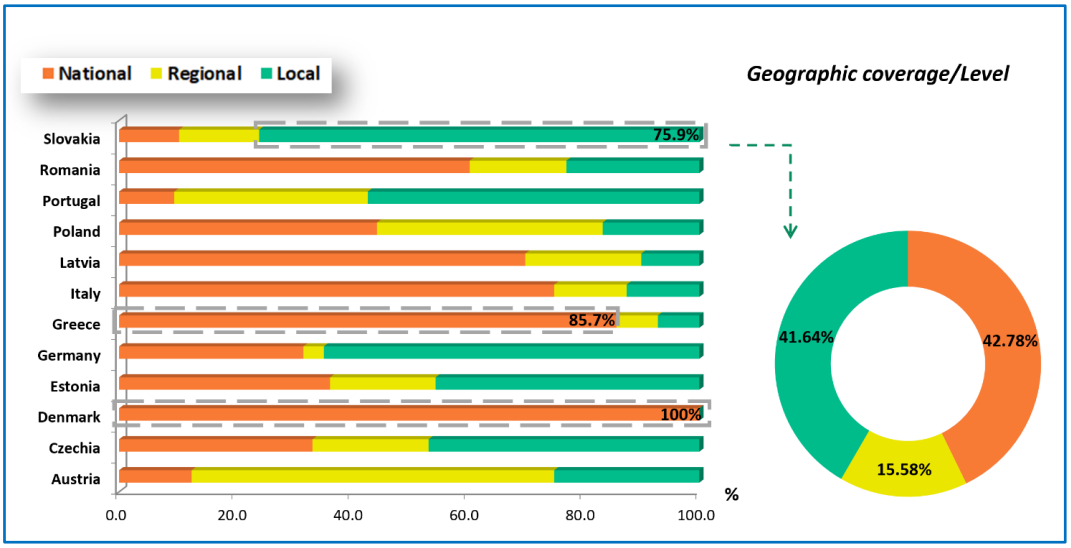

Fig. 35 Geographical coverage and multi-level representation of the stakeholders across the partners' countries

The largest group of stakeholders consists of policy/government (36.26%, or 128 stakeholders), followed by societal actors/community with 35.69% (or 126 stakeholders), industry/business (15.58%, or 55 stakeholders), and academia with 12.46% (44). An analysis of the data provided by each country involved in the project reveals significant differences in the main categories of stakeholders. For example, in Germany (65.9%) and Estonia (63.7%), societal actors/communities make up the largest group of stakeholders, while in Poland, policy/government is the primary area of activity for 72.2% of stakeholders (Fig. 36).

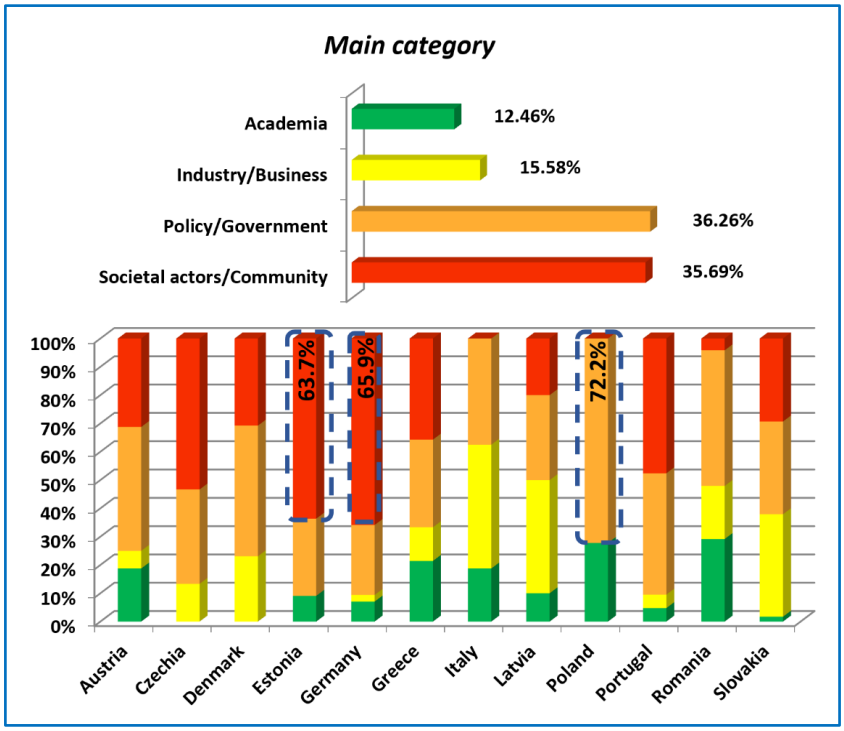

Fig. 36 Main stakeholder groups identified in Europe-LAND

There is almost an equal distribution between the public and private sectors. Regarding the sub-categories of stakeholders from each country involved in the project, the largest group consists of agricultural organizations/associations with 16.15% (or 57 stakeholders), followed by national

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authorities (15.58%) and research and academia (13.03%) (Fig. 37). Other represented groups include farmers, local authorities, regional authorities, non-governmental organizations (NGOs) and the business sector, all of which are relevant to the identified target sectors. However, foresters and land managers are underrepresented, accounting for less than 3% of stakeholders. While a balanced range of main areas of activity is represented, the analysis highlights the interconnected nature of these stakeholders. For smaller organizations, establishing networks and participating in such projects is often more challenging.

Given the large and diverse number of stakeholders, there is a level of complexity in determining their involvement and assessing their importance in the project. The results indicate that the majority of stakeholders are considered to have a high or medium level of importance (49.86% - high; 44.48% - medium), with only 5.67% rated as low importance (Fig. 38a).

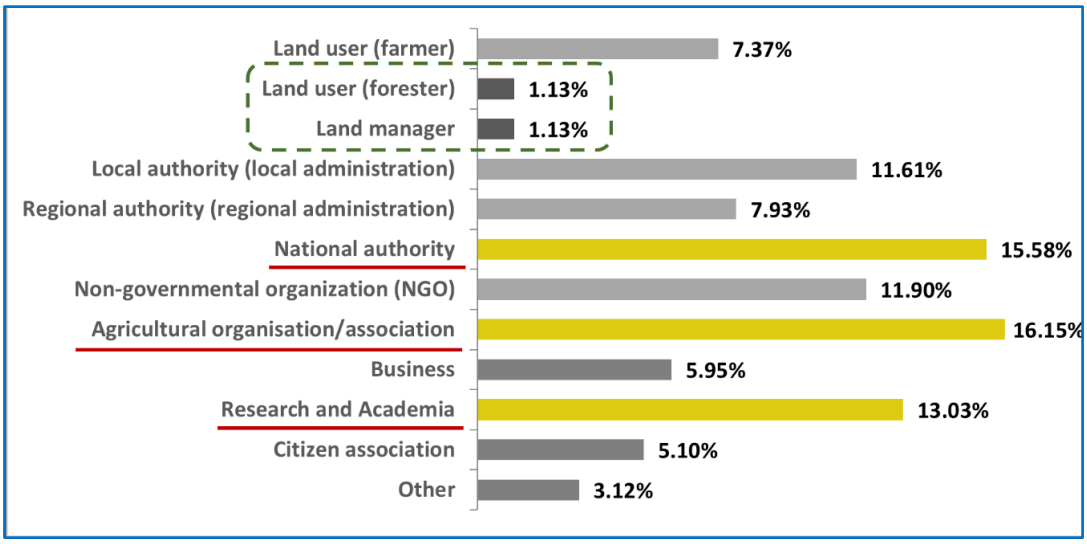
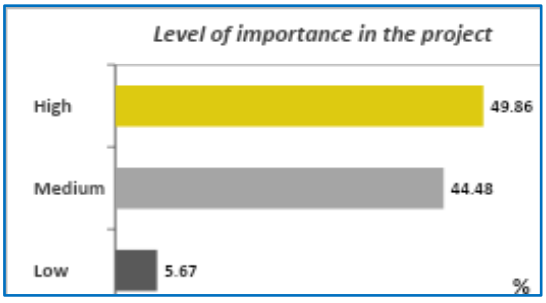


Fig. 37 Main categories of stakeholders identified as relevant for Europe-LAND project

Figure 38b shows the percentage of stakeholders classified based on the existence of previous contact or collaboration with the partners' institutions. Project partners reported having prior with around 47.31% of the stakeholders listed, indicating long-standing working relationships, established connections, or an existing network, as well as prior experience of having worked together. Conversely, there are stakeholders with whom partners have not worked in the past (48.16%), but this could actually be an advantage, as these stakeholders may bring new ideas, different working experience, and new resources, which could provide valuable support to the project.



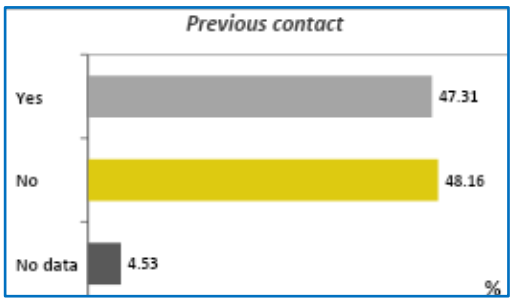


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Fig 38a; 38b Level of importance and previous contact with the stakeholders identified as relevant for Europe-LAND

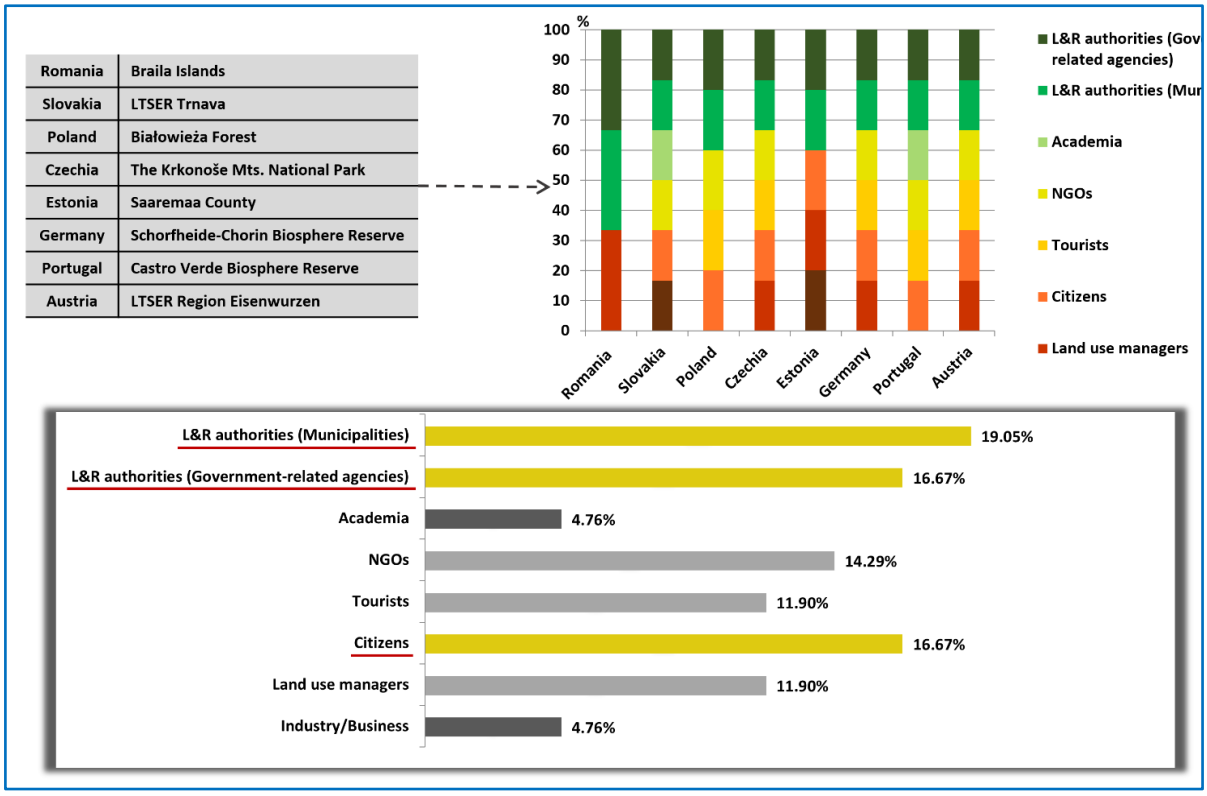

Figure 39 presents the 8th Europe-LAND case studies and the main stakeholders involved, grouped into 8 categories: municipalities, government-related agencies (local and regional municipalities), academia, NGOs, tourists, citizens, land use managers and industry/business. It can be observed that there is good coverage across all main categories in each of the 8 countries. “Municipalities” is the predominant group (19.05%), followed by “government-related agencies” and “citizens”, with an equal percentage (16.67%). The categories with the fewest representatives are “academia” and “industry/business”, which together account for less than 10% of the total.

Fig. 39 Networks of stakeholders for Europe-LAND case studies

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3. Organisation of the National „Mirror“ Workshops

3.1. Aim and format of the Mirror Workshops

The first event as part of the Co-Creation Roadmap was the organisation of a series of co-creation workshops targeting the national stakeholders in each of the 12 partners‘ countries in the period May-October 2024, following a similar format across all countries, thus being named as „Mirror Workshops“. The mirror workshop series, with the proposed title *“Present land use and land management challenges and future perspectives“,* aimed to increase stakeholders' understanding of various key factors contributing to past, present and future land use/land cover change, and potential pathways for sustainability, particularly addressing current and projected climate change and biodiversity challenges.

In addition, the workshop aimed to contribute to raising awareness among land use and land management stakeholders of future challenges related to the intensification of climate change impacts and biodiversity decline. By collaboratively exploring and assessing a country’s policy support towards making more sustainable land use decisions, the core idea was that participants would gain a deeper understanding of how policy is shaping national land use/land cover development.

Main objectives of the workshops focused on:

1. To discuss main national land use and land management-related sustainability challenges in the light of progressing climate change
2. To be informed about recent land use/cover changes in order to jointly explore the importance of key driving factors in shaping the potential future land use/land cover pattern in the country
3. To jointly identify and evaluate if and how existing policies (at the European, national and regional levels) can influence land-use decisions, promoting climate change adaptation and biodiversity conservation in the key sectors Europe-LAND works on, namely agriculture and forestry, and protected areas such as wetlands and biosphere reserves.
4. To derive visions of future land use trends in the perspectives of the year 2030 or 2050

Targeted groups of stakeholders: decision-makers (e.g. representatives from the ministries or related state agencies of agriculture, forestry sector, environmental protection, payment in agriculture etc.), research, environmental NGOs and land use and management associations, other relevant groups

An overview of the implementation of the events across countries is provided in Table 12.

Table 12. Date and format of the Mirror Workshops in the partners’ countries

No	Country	Date of the Mirror Workshop	Format	No. external of participants	Observations
1	Romania	13th June 2024	In-Person	21 participants	Europe-LAND event

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2	Germany	1st October 2024	Online	7 participants	Europe-LAND event
3	Portugal	14th October 2024	In-person	13 participants	Europe-LAND event (session) in the framework of a national conference
4	Latvia	16th October 2024	Hybrid	29 participants	Europe-LAND event
5	Poland	17th October 2024	Online	21 participants	Europe-LAND event
6	Greece	23rd October 2024	Online	19 participants	Europe-LAND event
7	Slovakia	10th October 2024, 17th October 2024 and 7th November 2024	In-person and hybrid	110+35+75= 220 participants	expert workshop, seminar with practical demo and national dialogue
8	Austria	14th October 2024; 18thNovember 2024	Online	11 participants	Europe-Land events
9	Italy	30th October 2024	Online	22 participants	Europe-LAND event
10	Czechia	18th October 2024	Online	6 participants	Europe-LAND event
11	Denmark	9th October 2024	In-person	200 participants	Expert exchanges in the frame of national land-use conference “Fremtidens arealanvendelse (Future land use)" in Aarhus, DK
12	Estonia	27th November 2024	In-person	32 participants	Europe-LAND event

The format of each workshop was decided by the partners, allowing for online, in-person, or hybrid events with a duration of 2-3 hours. Specific guidelines were developed to ensure a consistent structure while also giving partners the flexibility to adapt and shape the event’s content and vision. To facilitate a comparative assessment of the topics discussed with stakeholders, a set of essential topics and questions was identified as relevant.

In general, the workshops in each country followed the structure below. The results of the workshops are presented in this deliverable report following this structure.

- An introduction to the Europe-Land project
- Presentations of the team members covering topics as: land use/land cover changes as a key driver of global change, a brief discussion on the EU political context around Green Deal and relevant policies (e.g. Biodiversity Strategy, Forest Strategy, Climate Change Adaptation Strategy, Nature Restoration Law) and implications for land use and land management; past land use/land cover changes in each country outlining specific driving forces for each period, climate change contribution to land use/land cover change: future scenarios and impacts
- Discussions were open with a set of 3 questions using the online Mentimeter tool that targeted aspects as the most important land-related sustainability challenges in the country, ranking the main factors contributing to land use change from a given list, and if the participants consider that the current strategic provisions of agriculture, environment, and climate policies support the sustainable use of land in the respective country.
- Discussions were suggested to be directed toward the following main topics: Policies, Farmers, Solutions and Land Futures.

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- Conceptual maps of the discussions have been derived during the events or drawn by the partners after the event.

Ethical aspects have been also considered, a template of the stakeholder consent form has been prepared in English and was translated and adapted by each partner in the national language, as specified in section 2.3. The form was filled in before the event by each person attending it. To provide a unitary assessment of the workshop activities, a feedback form was prepared in this respect.

3.2. Results of the Mirror Workshops across partners‘ countries

3.2. Results of the workshop series across partners‘ countries

A detailed presentation of Mirror Workshops' results in each partner country is given in the Annex 1 of this report. Table 13 below synthesizes the discussions against the key aspects considered in the workshops: land sustainability challenges in relation to policies, farmers, solutions as well as a synthesis of Land Futures characteristics. Several conclusions can be drawn regarding the aspects examined during the mirror workshops. There is a good level of awareness and knowledge in terms of the main factors driving land use change: political and legislative factors together with economic ones are considered ranking first among all countries. In terms of secondary factors, stakeholders in some countries ranked social factors, while others environmental ones (e.g. climate change). At the open question "*Which are the most important land-related sustainability challenges?",* there are several answers received from the national-level stakeholders, which can be summarised along several directions: political aspects (lack of central strategic planning, regulations, unclear political view), environmental-related challenges (climate and climate change, water, drought, biodiversity, soil erosion and degradation) and awareness and knowledge-related challenges (management, knowledge, mindset, lack of awareness, stakeholders' interests).

A common challenge regarding legislative aspects across the countries is the lack of coherent and streamlined policies that align with sustainable land management goals. It is noteworthy that stakeholders across all countries showed general agreement in response to the question: *"Do you consider that the current strategic provisions of agriculture, environment, and climate policies support the sustainable use of land in your country?"* Most participants indicated that these provisions support sustainable land use to only a small or very small extent. Conflicting regulations, insufficient integration of environmental, agricultural and economic dimensions, bureaucracy and stronger, but simplified, legislative support are needed. Furthermore, farmers across all countries face economic pressures with limited financial and advisory support, while more difficulties exist in actively involving younger generations. Thus, the importance of education and awareness campaigns was emphasised, as a solution that can inform and educate old and young farmers regarding sustainable agriculture. Other solutions mentioned include agro-voltaics, advanced technologies and sustainable agricultural practices. As for the future, emphasis was given in balancing ecological preservation with economic development. To do so, adaptive agricultural practices, strong protection against industrial encroachment, safeguarding arable land from urbanisation and industrial use, water management, and well-planned protected land uses were suggested. It has to be mentioned, that in all workshops, EU was acknowledged as a supporter, but the EU policies horizontally implemented, lead to great bureaucracy and national lack of vision, as each country has its own characteristics and faces different

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challenges according to its economic, social, cultural and environmental background, as well as the challenges to be faced by the climate change.

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Table 13. A synthesis of discussions during the national Mirror Workshops

Country	Policies	Farmers	Solutions	Land Futures
Austria	EU politics: Green Deal as booster for organic farming; implementation of existing laws (nature restoration); fear that EC will put less emphasis on environmental issues in the future; Need for coherence between scientific findings and the development of policies; Need for collective approaches to collective problems and change of priorities; Necessary long-term changes are politically unattractive in the short-term; Support the use of agro-photovoltaic systems; CAP subsidies: EC increasingly wants to demonstrate social benefits of these payments Climate/environment and/or biodiversity impacts of measures becoming more important, it depends on the design of CAP 2028+	Digitalization and precision farming; for simplification of bureaucratic processes; concern of more bureaucracy: EU sustainability reporting; need for paradigm shift in funding; complex funding requirements; more flexible management requirement	Sufficiency and reduction of meat consumption/production; Reduction of land for animal feed, instead national protein strategies; Supporting non-technical solutions instead of relying on "technological miracles" to solve problems; Land/biodiversity/ESS conservation as a solution to sustainability problems; combined with payment for these services; Dialogue between different groups (farmers vs. conservationists) and (economic/agricultural) chambers and regional actors; Prioritizing integrated spatial planning/soil protection policies; Reducing bureaucracy; Raising awareness of the value of biodiversity/ESS/food production processes, including through financial recognition of maintaining ecosystem services	harmonized land use for basic societal needs and ecosystem services; sustainable and inclusive urban-rural land use integration; promotion of diversified and resilient agricultural systems' reduced conflicts over resources, promote a sustainable agri-food sector
Czechia	Determining the shape of farming in the EU - influenced by the EU CAP; Sufficient agricultural production & sufficient arable land are ensured by political drivers, risk of water, greater instability of global system; Greater biodiversity and climate change adaptation through increased support for non-productive functions of agriculture, greater restrictions on non-compliance with environmental standards, and reduced administrative burden; Local production	Weak role of the owner vis-à-vis the user of agricultural land (in the Czech Republic, fragmented ownership structure, but large entities farming on agricultural land - large part of agricultural land under lease, potential threat Relationship between owners and users of agricultural land	Subsidies for landscape, soil and landscape protection are in the public interest. Not enough farmland to allow younger generations to actively engage in land. Support young farmers Examine multifunctionality farmlands, considering also the warming and weather extremes	Past developments should aid in predictions of future developments Concentration of agricultural land in larger farms (necessary to preserve and support family farms) Reconcile sustainable business with Economy Increased intensification of agriculture in fertile areas Loss of agricultural land in core areas-growth of built-up areas (urbanisation)

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	promotion; Drafting forest policies and strategies on wood use; Tougher legislation & greater institutional protection of land; Farmers education to adapt to current trends; In the event of an adverse international situation (e.g. Russia-NATO conflict), permanent grassland can be converted to arable land and help with food security	create problems in relationship to land Ownerrs disconnected from reality (one of the main drivers) Owners often hinder environmental change Large number of small owners creates problems in the implementation of landscape measures	Carbon storage in soil Climate change: (a) shift of usable land towards the north. (b)Change in the structure of imports, changes in agrotechnical practices and crop mix, (d) change in landscape due to wind farms - (e) emphasis on water management in lowlands Improve territory resilience Translate strategies into concrete measures	New forms of farming: agroforestry Raise awareness on the importance of quality land for the future Carbon Storage Erosion monitoring & prevention Better water management Protected agricultural land through better legislative protection Slight increase in land farmed by private farmers Land is increasingly used for energy production
Denmark	We need governance tools to target the measure to the areas that can deliver. New design of policies: support schemes and tax. We need a national strategy for a comprehensive national plan (national planning) We need competition between different policies to speed it up.	Land owners as landscape manager and as forest owner. A lot will like to participate, but the financial instruments need to be in place. Main barrier is that we live in the past. Eg agriculture was very important historically, but not now. Different jobs today, agriculture needs accept the reality	Large-scale land conversion from farm land to forest (afforestation) and wetlands CO2 tax on agriculture Reduction of allowed amount of fertilizers (N reduction) Increase of protected areas to 20% (currently 10%) DKs climate aim of 110% reduction in 2050	Prioritization of Nature and Biodiversity Sustainable land use Forests and Green Spaces Restricting Urban and Industrial Expansion Water and Groundwater Conservation Renewable Energy and Local Ownership Recreational Opportunities and Community Involvement Balanced Food Production
Estonia	1. Transparent Regulations: • Clearly define protected areas and ensure policies are consistently enforced without loopholes. 2. Support for Local Communities: • Strengthen regional policies to empower local stakeholders and maintain rural vitality. 3. Integration of Conservation and Development:	Applying for subsidies is overly complicated Small producers give up, while large ones have staff to handle paperwork Farmers have to manage everything: land cultivation, sales, and reporting.	1. Education and Awareness: • Integrate nature education early in schools to foster ecological awareness. • Promote public understanding of sustainable practices to enable better land stewardship. 2. Support for Small-Scale Farming: • Encourage small-scale farming by reducing bureaucratic barriers and	• Desired Future: A landscape dominated by small-scale, sustainable farming, complemented by biodiversity-friendly practices. Urban-rural collaboration and well-managed renewable energy projects would coexist harmoniously with food production and conservation efforts. • Undesirable Future:

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	• Encourage sustainable infrastructure projects that minimize ecological impact while fostering economic growth. 4. Invest in Education and Maintenance: Revive nature education programs and allocate resources for ongoing maintenance of restored habitats	Bureaucracy is overwhelming; handling the application process is a challenge. Farmers see climate impact on their own fields. Farmers must adapt, but there's no information to guide them. Information is available if you research it yourself Interest in organic farming is declining; many are quitting. Every village needs a "local eccentric" to keep traditions alive. Urbanites moving to the countryside create their own version of rural life.	providing targeted financial support. • Develop local and international markets for small scale farmers to sell their products and focus more on their main field – production. 3. Technological and Innovative Practices: • State supports the adoption of new agricultural technologies and climate-resilient crops to adapt to environmental changes. • Promote the use of sustainable machinery and farming techniques that reduce dependency on intensive methods. 4. Land Use Planning and Policy Reform: • Prioritize mixed land use, balancing food production, biodiversity, and renewable energy projects like solar farms. • Regulate the conversion of agricultural land to industrial purposes to preserve farmland. 5. State and Stakeholder Roles: • Strengthen state policies to buy and preserve protected lands, ensuring sustainable management. • Offer incentives for biodiversity preservation and sustainable agricultural practices.	Intensified urbanization, abandoned rural areas, unsustainable industrial farming, and degraded solar parks replacing fertile farmland. • Key Drivers: Climate change, technological advancement, economic pressures, and population dynamics will play pivotal roles in shaping future land use.
Germany	Land Use conflicts expected due to environmental, biodiversity, and climate policies. The Land Use policies must balance environmental goals with profitability to support farmers' livelihoods	Climate and biodiversity issues need more time and space to be correctly addressed, as the willingness to embrace change and take action depends on the	A conflict between high input versus sustainability remains, hindering the necessary transformation. Incorporation of externalities is something that needs to be addressed	**Land Use & Management** -Technology integration can be used to efficiently cultivate available land (e.g. small-scale fields worked by autonomous machines) and innovation adoption to reduce total emissions

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	Urban development reduces agricultural land raising the need for efficiency EU view is too fragmented and more European-wide thinking is needed including a good approach embracing a broader line of thinking	practices followed in each region and the political environment Bureaucracy hinders farmers who actively seek to build knowledge for change. Younger farmers and students are more motivated towards new practices but existing infrastructure does not allow them to	(establish the "real price" of each product) The economic dimension of agricultural production could be linked to other dimensions, new value chains, and new products, to ultimately change the EU consumption patterns and aid in environmental protection. This should be depicted in a respective legal framework	-Circular economy as a driver to reduce pressure on land -Efficient use of existing resources -Effective and sustainable use combined with economy: more biodiversity areas (semi-natural landscape elements), peatland rewetting and wet management of peatland soils, diversified income **Biodiversity** -Diversified land use (biodiversity-friendly) -The majority of farmers' income comes from sustainable resource use -Land-sparing rather than land-sharing is the main concept to promote biodiversity **Other** -Active citizen participation in land use -Transition away from large-scale and highly intensive systems -Plan security for farmers -Transition away from animal-based systems
Greece	Significant shifts in land use over the coming years due to environmental policies, climate adaptation needs, and biodiversity conservation efforts. Policies promoting renewable energy, like solar farms, sometimes repurpose productive agricultural land, highlighting a trade-off between energy needs and traditional land uses.	-Mixed perspective on accessing funding for agricultural and environmental interventions, largely influenced by the structure and effectiveness of subsidies. -Gap in the incentive systems as they don't yet align with	-The need for a holistic approach to sustainable land management, calling for a comprehensive spatial plan that integrates residential, agricultural, and tourism development with clear land use guidelines. -Education and awareness to foster responsible resource use, especially in water management.	The vision is to build resilient communities through strategic, sustainable land management that harmonizes urban development, agriculture, tourism, and biodiversity conservation. The aim is to create cities and towns where green spaces enhance the quality of life and environmental resilience. Urban planning should prioritize a balanced development with clearly defined land-use zones that integrate local and European environmental goals. Participatory planning, involving local

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	Balance land use and biodiversity conservation - policies to integrate reforestation and carbon credits to incentivize sustainable practices.	broader environmental objectives. -Challenges emerge in sustainable agriculture practices, where subsidies inadvertently increase livestock, sometimes leading to resource strain. -While there's interest in organic methods, barriers such as lack of environmental awareness, limited advisory support, and complex subsidy requirements limit farmers' capacity to adopt sustainable practices. -Agronomists, who ideally would serve as advisors on best practices, are often financially incentivized to act as product suppliers (e.g., fertilizers), which may prioritize sales over sustainability. -A need for restructured funding and advisory systems that focus on environmental performance and sustainable land management.	-Economic incentives should support young farmers, streamline bureaucratic processes, and help those with limited financial means access sustainable practices. -Policy should lead economic directives, not the reverse, to ensure genuine sustainability. -Concerning renewable energy, participants acknowledged its importance but urged a more balanced approach that considers land conservation, especially agricultural areas currently overtaken by solar farms. They proposed that renewable energy projects follow strict spatial regulations to protect the environment and that the economic benefits of these projects be reflected in lower electricity costs for consumers. -Participants concluded that an independent, self-sufficient approach is essential for both land sustainability and economic resilience.	communities in decision-making processes, should be fundamental to ensure that land-use policies reflect both the needs and values of the citizens. In rural areas, the focus should be on promoting efficient water reuse and conservation systems and the construction of small-scale infrastructure like micro-dams. Tourism development should shift towards sustainable models, preserving natural landscapes and biodiversity while creating economic opportunities. Eco-housing and energy-autonomous settlements should serve as the foundation of the residential areas. A robust legal framework should ensure that economic development adheres to environmental laws, supported by strong oversight to prevent misuse of protected areas.
Italy	Standardised Data and Carbon Credits (establish a unified system for tracking carbon sequestration in agricultural soils)	Access to Land and Financing (high land costs & limited availability for affordable	Financial Support and Land Access Schemes Simplification of Bureaucratic Processes	Diverse future land use management. A consensus is that future land use management must prioritise sustainability emphasizing renewable energy

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	Young Farmer Support Renewable Energy Balance (RES installations on non-arable lands, promote agri-voltaic practices to preserve productive soil base)	credit create barriers for new entrants) Bureaucracy and Compliance Costs (the need to simplify procedures is needed) Climate Change and Environmental Pressures (prohibitive costs to adapt to climate change and regulatory requirements without financial support) Technological Adaptation to new technologies (e.g. precision agriculture tools, digital monitoring systems, advanced irrigation techniques) is challenging and continuous support is needed (both educationally and financially)	Incentives for Sustainable Practices Support for Technological Adoption Promoting Agri-Voltaics	integration, carbon sequestration, and preserving productive agricultural land. More coherent policy framework to align agricultural and environmental policies within the context of the upcoming EU's reforms Safeguarding arable land against unnecessary industrial use Empowering young generation with tools and opportunities to engage in sustainable practices in farming
Latvia	-Unclear political vision -EU unified policies cannot be applied in Latvia	-Fewer restrictions and long term planning are requested by business owners -Disagreement with EU policies	-Align stakeholders' interests and long-term targets (balancing business and environmental goals) -Better education is needed -National defense is something that also needs to be considered as Latvia borders with aggressor countries	-Balancing environmental, political and economic needs -Intensive land use (less and less unused areas) -Better planned EU support (increased and unplanned support leads to land occupation) -Integrated technologies -Climate policy needs to include land use management -Improved agricultural practices by respecting the environment and by considering the prevalence of

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				extreme weather conditions and the alteration of the hydrological regime
Poland	- Poland has not yet developed national plans for natural resource reconstruction -Initiating a dialogue with stakeholders regarding biodiversity conservation is still a great challenge -Financial support should be given to local government to protect biodiversity and land use, as well as establishing a "right approach" to spatial planning -Conflicts between land uses are expected because of the limited amount of land in Poland	-Bureaucracy is a great barrier for agri-environmental subsidies -Mixed perception of eco-schemes by farmers. -Main driver for farmers' choices: finances -Challenges remain for organic farming (low productivity in a huge competitive field, small share of organic farming within global agriculture, market globalisation)	-A Wetland Strategy is under development in Poland -Projects implemented by the Department of Forests, forestry and Hunting to limit logging in forests	-Escalating social & environmental conflicts -Greening cities & focus on quality of life is needed, but challenges still remain -Land Management Future in Poland is seen optimistically as more people recognise the importance of greening urban spaces, sustainability and careful planning.
Portugal	inconsistencies between policies and allocated funds, conflicts between policies in the same area (e.g. water), need for crop regulations, Legislative differences between public and private irrigation, not enough consideration to science in policies	essential role of farmers in conservation, low support to farmers regarding conservation, farmers need to have their voices heard in decision making	effective communication and raising awareness; support and incentives; knowledge and practices; diversity in agricultural practices; effective management	Strengthen Collaboration and Knowledge Sharing Invest in Sustainable Practices Adaptation and Resilience to Climate Change Enhance Regulation and Public-Private Collaboration Tailor Policies to Local Conditions
Romania	political engagement with technology and environmental issues, need for policy coherence, the unused potential for organic farming, weakness in soil conservation laws and directives, farmer discontent with changing agri-environment policies	decline in organic farming and livestock farming, compensations for farmers for conservation activities, funds, unequal regulatory environment for EU farmers compared to non-EU farmers	education against food waste, windbreaks as a biodiversity solution, curriculum adaptation, technology development, expansion of irrigated land, adapted genotypes, collaboration with meteo service, policymakers must address the restrictions of EU farmers compared to the non-EU farmers (double standards)	Adopt Advanced Technologies Integrate Sustainability and Biodiversity: Balance Ecology and Economics Strengthen Political and Legislative Frameworks Adapt to Climate Challenges: supporting small farmers, and adopting mixed land use systems like agrovoltaics and urban agriculture.

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Slovakia	need to increase participation in ecoschemes of farmers, EU green targets are very high and cannot be easily met, need for simplified policies, need for a *national policy and a long-term strategy for soil conservation, ecosystem restoration, creating methodological guidelines for land management*	need relevant data from farmers on emissions, fertilizers and pesticides, advice lacking, local governments sell land to foreign owners, farmers not involved in preparing the strategic documents, carbon farming, medium-size farmers (500-4000 ha) mostly affected	increase participation in ecoschemes; Sustainability and competitiveness need to be reconciled in legislatio; Policies need to be simplified, need for a national policy and a long-term strategy for soil conservation whole-farm ecoscheme; Restoring the ecosystem functions of the soil · "pro-farmer" ministerial perspective; to focus more on water and the aquatic ecosystem.	Sustainable Land and Resource Management Integrated Ecosystem and Biodiversity Approach Economic and Social Support for Farmers Innovation, Education, and Technology Policy and Cooperation

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A key objective of the mirror workshops was to develop a vision for **Land Futures**, enabling an understanding of potential pathways toward sustainable land management while also deriving future land scenarios aligned with stakeholders' perspectives. Although partners approached the concept of future land perspectives differently during the workshops—either by emphasizing what sustainable land management means to stakeholders or by encouraging them to envision various potential futures for land—certain general characteristics can be identified through an analysis of stakeholders' quotations. Overall, the key characteristics identified by stakeholders reflect a dual vision of the future. On one hand, there is an optimistic outlook envisioning sustainable land management that balances economic, social, and environmental aspects. On the other hand, a more pessimistic perspective emerges, characterised by increased land fragmentation and polarization, conflicts, economic pressures, fragmented policies, and intensified impacts of climate change.

The narratives for the future scenarios (Land Futures) were developed through a content analysis of stakeholders' responses to the questions: 'What will the future look like?' and 'How do you envision the future use of land?'. In the first stage, the analysis was conducted separately for each country by carefully examining stakeholders' quotes, identifying recurring themes and patterns, and clustering key characteristics of the future against the identified future. Usually, 3-4 potential pathways have been identified for each country. In the second stage, the identified scenario characteristics from individual countries were further aggregated to uncover patterns relevant to the broader group of countries. The in-depth analysis of the quotations provided by partners on stakeholders' visions for potential land futures identified four distinct future pathways. These pathways were consistently reflected in the perspectives of stakeholders across all countries. The preliminary narrative of Land Futures integrating all mirror workshops is given below.

1. **An Integrated Sustainable Future.** It defines a balanced future with a sustainable intensification of agriculture in fertile areas, while taking sustainability measures, such as carbon storage and erosion prevention, that ensures the co-existence of small-scale farms with the larger ones, with prevalence of agroforestry practices; empower young farmers to promote sustainable practices; strong political and legislative framework for land protection and sustainable land management, Increased public-private collaboration and enhanced stakeholder engagement for better water management, including soil water retention, flood control measures, and conservation-focused practices; coherent landscape planning with the involvement of all actors; Socioeconomic and environmental policies are harmonized, leading to widespread adoption of sustainable land management while balancing economic efficiency and environmental conservation
2. **A Fragmented Future -** defines a more polarised future in terms of an uneven land use, with stronger intensification/extensification patterns, modern, technologized areas coexist with "abandoned" and overexploited regions; risk of environmental degradation in the overexploited fertile areas; increased pressure on land near the cities due to increased urbanisation and loss of arable land, family farms struggling to compete with large farms, increased competition on land due to the needs for energy production (solar, bioenergy), limited adaptation to climate change for some regions; lack of a strong political context that leads to environmental degradation, increasing the consequences of extreme climate events, social conflicts over property and inconsistent adoption of nature-friendly practices; land grabbing, technological advancements remain underutilized or poorly distributed, with no coherent policy to integrate their benefits across sectors.
3. **A Climate Resilient Future -** promotion of agri-environmental measures, with widespread adoption of greening practices like organic matter management, erosion monitoring, and carbon storage initiatives; a robust land-use policy that protects agricultural land while enhancing water

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management; new farming system such as agroforestry; regenerative agriculture, focusing on soil conservation, water management, biodiversity, and climate resilience; mixed land use models, combining both traditional knowledge and advanced technologies; increased collaboration among stakeholders for appropriate planning; private farms expand, balancing economic profitability with sustainability, supported by examples of best practices and government programs like the Green Deal for Europe; farmers adequately incentivized through targeted subsidies for sustainable practices and for providing ecosystem services; adequate legislative framework for efficient use of resourcing, balancing socioeconomic development and environmental protection promoting climate change resilience and rational land use; education and awareness for nature-friendly practices.

4. **A Technological Future -** AI-driven decision-making ensures efficient, data-based policies at all levels, minimizing political bias and enabling centralized, homogeneous governance; use of advanced technologies such as drones, GPS, robotics, and agrovoltaics, with sustainable solutions like urban agriculture and automated monitoring; precision agriculture to maximize productivity while minimizing environmental impact; large farms adopt innovative solutions to enhance efficiency and crop diversity, while family farms thrive with better access to technology and government support; local markets are strengthened, reducing reliance on imported ultra-processed foods and encouraging diverse crop production

This is a draft analysis of the land futures discussed in the mirror workshops. A more advanced analysis will be presented in a joint paper that the research team will prepare in the near future, and the identified future pathways may be subject to change.

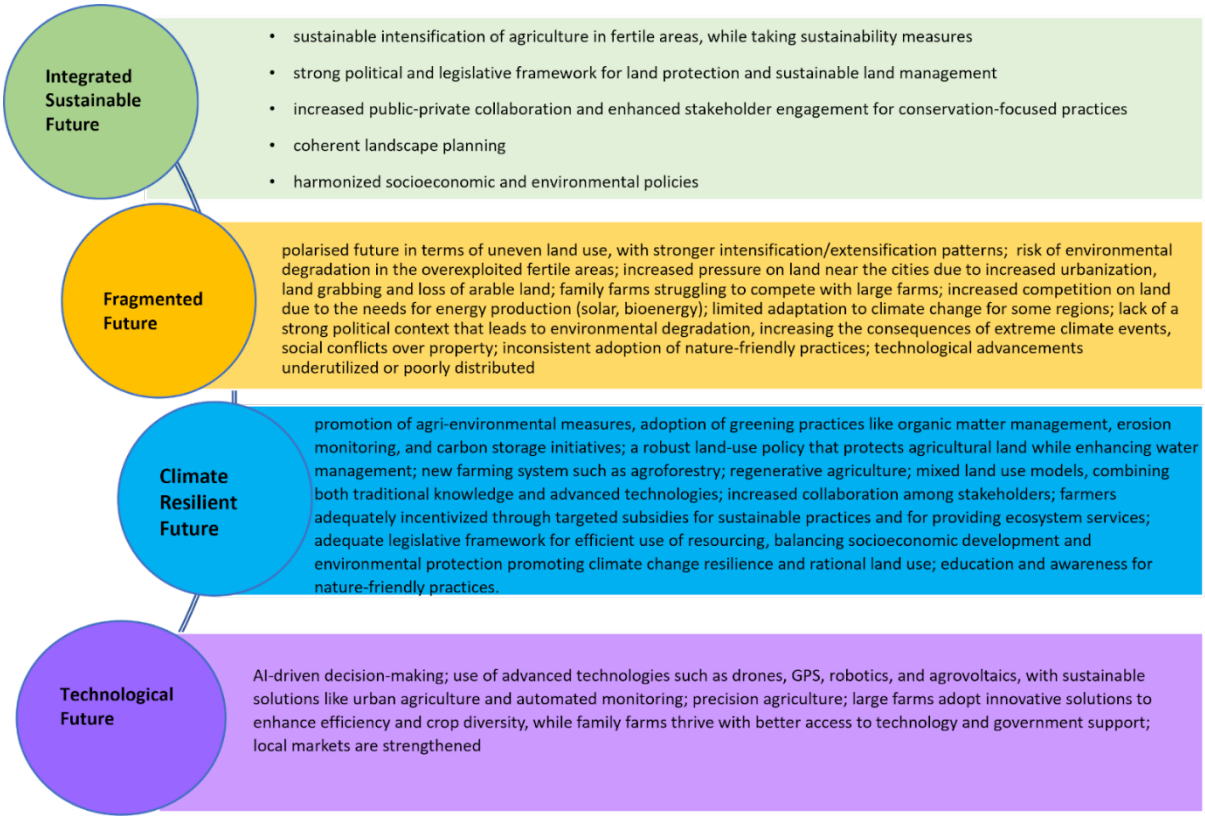

Fig 40. Co-created Land Futures for the partners' countries during the Mirror Workshops

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In line with the Europe-Land Living Lab Framework, each participatory activities proposed in the roadmap are followed by a reflection phase, where partners share together ideas regarding the approach and lessons learned to adapt and improve future activities. The reflection exercise after the Mirror Workshop took place on November 22, 2024, during the virtual Project Management Board. Partners received several guiding questions targeting various aspects of a living lab approach: experience regarding the role of diversity of the stakeholders, workshop structure, team management, outcomes of the workshops, feedback received from stakeholders and how the partners defined the success of the workshop.

Experiences with organising mirror workshops events across countries lead us to derive some general conclusions in terms of what worked, which were the main challenges and what to improve for future.

Stakeholders. Partners widely recognized the high level of expertise and knowledge demonstrated by participants. They noted key benefits for stakeholders attending the meeting, including opportunities for knowledge exchange, sharing opinions among diverse groups, networking, and engaging in active discussions during the event. While some partners appreciated a good diversity of stakeholders attending the event, others observed limited participation and diversity. A consensus emerged that a critical stakeholder group—farmers—was notably absent from the workshops in Romania, Greece, Poland, and Germany. Looking ahead, the primary challenge will be to maintain stakeholder engagement by keeping them informed and actively involved in the project's activities through regular updates and invitations to future actions.

Workshop structure. Partners generally appreciated the use of the Mentimeter tool, which effectively encouraged discussions and engaged all participants. The standardized structure followed by all partners was also well-received. For the presentation segment of the workshop, some partners enhanced the sessions by inviting external experts from relevant fields, such as academia or government ministries. However, the proposed workshop structure presented challenges in some countries. In particular, the number of questions and topics exceeded the time allocated for discussion, especially during online workshops, where time constraints were more pronounced compared to in-person events, which allowed for extended discussions. Additionally, ensuring active engagement from all stakeholders was challenging, as not all participants contributed equally to the discussions.

Team. Partners acknowledged that their teams possess strong communication and facilitation skills for such events, complemented by solid expertise on the topic. The primary benefit for the teams was seen in the new connections established with stakeholders, gaining insights into legislation, engaging in discussions on EU agricultural policy, enhancing interaction skills, networking, and deliberating on preliminary results. However, a key challenge was the difficulty of actively engaging partners in discussions. To address this, incorporating more interactive and visually engaging methods and tools is recommended for preparing future events.

The *key indicators* mentioned by the partners to define the success of the mirror workshops were linked to the participation of a large number of stakeholders from various groups as well as the diversity of the discussions promoted.

Outcomes. There are various scientific outcomes and conclusions out of the mirror workshops' events, emphasised by partners in each country.

Germany. Main conclusions, linked to the way the discussions evolved, can be summarised as follows: there is a high political and societal pressure for structural changes of agricultural systems in the EU (mentioned by all participants); bureaucracy as major obstacle (brake) on the acceptance of

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sustainable farming methods in the EU; land use conflicts in the EU are likely to grow, also triggered by current CAP; innovations and technology as important keys to sustainable land use in the EU; diverse use of agricultural landscapes; planning security for farmers is important; politics and economics are the main keys for sustainable development.

Greece. It was expressed that ultimately land uses are formulated by economic factors and not legislation, social or environmental ones. Furthermore, EU grants have much bureaucracy and affect land uses as farmers' choice is made based on the grants received.

Italy. Key conclusions targeted the need for high-resolution satellite data & automated systems (AGEA), which are critical for monitoring land use; the need for standardized carbon credit systems to incentivize sustainable practices; barriers faced by young farmers: land access, financing, and incentives and the need for promoting renewable energy through agri-voltaics; participants were much more engaged in addressing the open questions compared to using Mentimeter; bureaucracy.

Austria. A key conclusion emphasizes the critical role of political will in ensuring sustainable land management. It also highlights the current and future challenges arising from the multiple uses of land (e.g., for food, energy, etc.) and the potential conflicts that may emerge from competing interests, underscoring the importance of collaboration.

Poland. It was suggested by the respondents that future similar workshops should address topics such as a strategy for promoting sustainable land use, issues related to biodiversity, and include farmers in the discussions; issues related to the open questions, as the level of engagement and participation was lower than expected

Romania. The main conclusions of the discussions emphasise the extended role of political decisions in supporting sustainable land management; the need for policy coherence and support to meet sustainable land management; the importance of adopting new/advanced technologies and solutions.

Portugal. The workshop highlighted a significant disconnection between public and private policies, particularly regarding resource use and agricultural practices, which often results in conflicting regulations and management issues. The stakeholders also enhanced the importance of effective communication and raising awareness about the discussed topics to achieve clear solutions, particularly in the context of science and public understanding.

Czechia. The workshop identified and discussed the main problematic areas and specifics of Czechia in agriculture and land use, in particular the relationship between owners and users of agricultural land.

Slovakia. There are few aspects that have been emphasised during the workshop: efforts needed to promote farmers engagement with ecoschemes, need for legislation to balance sustainability and competitiveness, need for the policies to be simplified and be properly monitored, the need for national policies and strategies for soil conservation that prioritises ecosystem restoration, the need for water resources management; land ownership and the sale of land to foreign owners.

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4. Conclusions

Living Labs (LLs) are participatory, user-centred research environments focused on co-innovation by engaging diverse stakeholders—including citizens, researchers, businesses, and governments— to develop, test, and validate new solutions in real-life settings. Emerging in the late 1990s, LLs have expanded, especially within the EU, which has supported LL initiatives to address societal challenges and enhance economic competitiveness, leading to the establishment of the European Network of Living Labs (ENoLL). LLs follow the key principles: active user involvement, real-life settings, multi-stakeholder collaboration, multi-method approaches, and co-creation.

LLs operate within the Quadruple Helix framework (citizens, government, industry, and academia) and sometimes the Quintuple Helix, which adds the natural environment, to foster sustainable innovation. This structure enables LLs to adopt multidisciplinary and transdisciplinary approaches to problem-solving, with the goal of bridging action-knowledge gaps.

The LL approach differs from traditional participatory methods by involving users continuously throughout all design phases, from ideation to implementation. Key areas of stakeholder engagement include collaborative decision-making, local problem-solving, and empowerment in decision-making and real-world feedback loops. This long-term engagement promotes user-driven innovation that closely aligns with users' needs.

In conclusion, LLs are flexible, collaborative platforms for real-world experimentation, fostering innovations that are both sustainable and community-oriented. Their transdisciplinary, multi-stakeholder nature makes them instrumental in addressing complex societal and environmental challenges. By supporting knowledge exchange and enabling community-driven solutions LLs promote sustainable practices and effectively address diverse regional needs across various sectors.

The theoretical and conceptual framework of Living Labs is complex and diverse, with different frameworks adapted to various fields of research or the topic of interest, as such there is not a widely recognised framework to tackle all these aspects. Generally, there are frameworks targeting the organisational aspects of the LLs (e.g. dealing with how to engage and recruit stakeholders), or frameworks that target a specific field of interest. Among the latest ones, close to the objectives we pursue in Europe-LAND, place-specific frameworks (such as Rural or Urban Living Labs, agroecosystem or agricultural Living Labs) or integrated frameworks (e.g. sustainability frameworks) are the most relevant ones.

As identified from the literature review there is a lack of studies on sustainability, agricultural and rural living labs, documenting positive long-term outcomes of such initiatives and insufficiently documented studies evaluating their success rate across various scales.

Since Living Lab approaches require a complex process for involving multi-stakeholders to co-create innovative solutions for real-life aspects, it is essential to ensure flexibility of the approaches and a permanent adjustment of their actions, an important aspect that is considered also in Europe-LAND.

The key stages of a living lab approach identified in the literature as well as challenges, main lessons and good practice examples have guided in developing the Living Lab conceptual framework of Europe-LAND. Considering the project's general objectives and WPs research question, the framework aims to embed the co-creation principles across WPs either to serve in achieving tasks' objectives or to validate the research results. The unique feature of Europe-LAND LL Framework is the multiple level approach,

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to engage differently the stakeholders at the national level or the ones at the regional and local levels (in relation to the case studies).

Europe-LAND Living Lab framework was developed based on an extensive literature review combined with an integration of specific research needs and questions of the project tasks, including the perspectives offered by the variety of case studies in the project. The methodological framework outlines the key steps of the LL approach derived from the literature, including co-design, real-life experimentation/real-life environments, co-creation, co-evaluation, and iteration, facilitating its participatory and dynamic process. It has been designed as a practical framework, context-specific considering the project's objectives, flexible and adaptive throughout the project life. A continuous reflection process involving the partners has been proposed to better adapt the methods, tools and research interest to stakeholders' needs and perspectives in each country. The associated Roadmap, which follows 2 main pathways (at national, regional and local levels), includes workshops, expert interviews and questionnaire surveys as main methods for interacting with the stakeholders. The framework is built considering the basic ethical principles as the protection of participant rights and privacy; transparency and informed consent of participants; equity and inclusivity of participation; sustainability and long-term impact.

In the Europe-LAND project, the structure of the stakeholders corresponds to the Quadruple Helix model, a model suited for promoting knowledge sharing across different institutional and spatial levels through multi-stakeholder collaboration. The main stakeholders' groups are represented by the national, regional and local authorities, societal actors, industry and academia. Among these, the largest group is represented by agricultural organizations/associations, national authorities, research and academia, NGOs, the business sector and land managers (farmers and foresters). Each stakeholder group is targeted by different participatory approaches, with a continuous update of the stakeholders' database in the project and a stakeholder strategy has been developed in WP7.

The Mirror Workshop series, the first participatory event proposed in the Europe-LAND Roadmap, was organised in the period June-November 2024 in the partners' countries and allowed a discussion with the national level stakeholders of the current land sustainability challenges of countries, in relation to policies, farmers, allowed to jointly identify solutions, and to co-create potential scenarios for future. As a synthesis of the discussion, 4 potential pathways have been jointly identified by stakeholders in the countries, from more green and sustainable potential pathways (Integrated and Climate Resilient Future), to a more pessimistic vision (Fragmented Future) and a technological-driven future.

A common challenge identified in all mirror workshops points to the legislative aspects in terms of the lack of coherent and streamlined policies that align with sustainable land management goals. Conflicting regulations, insufficient integration of environmental, agricultural and economic dimensions, bureaucracy and stronger, but simplified, legislative support are needed. Moreover, the need for data integration, for sharing best land management practices, financing and the role of subsidies, young farmers' engagement and agricultural policies, simplification of bureaucracy and administrative requirements, need for dialogue among different actors, education, awareness and mindset change were among the common topics of interest discussed during the workshops.

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References

Akasaka, F., Mitake, Y., Watanabe, K., & Shimomura, Y. (2022). A framework for 'configuring participation'in living labs. *Design Science*, *8*, e28, http://doi.org/10.1017/dsj.2022.22.

Akinnagbe, O., Irohibe, I. (2014), *Agricultural adaptation strategies to climate change impacts in Africa: a review*, Bangladesh J. Agril. Res. 39(3): 407-418

Alamanos, A., Koundouri, P., Papadaki, L., Pliakou, T., & Toli, E. (2022). Water for tomorrow: A living lab on the creation of the science-policy-stakeholder interface. *Water*, *14* (18), 2879.

Almirall, E., Lee, M., & Wareham, J. (2012). *Mapping living labs in the landscape of innovation methodologies*. Technology innovation management review, 2(9).

Alotaibi, B.A., Kassem, H.S., Nayak, R.K., Muddassir, M.(2020), *Farmers' Beliefs and Concerns about Climate Change: An Assessment from Southern Saudi Arabia*, Agriculture, 10: 253

Andraczek, K., Weigelt, A., Hinderling, J., Kretz, L., Prati, D., & van der Plas, F. (2023). Biomass removal promotes plant diversity after short-term de-intensification of managed grasslands. *PLOS ONE, 18* (6), e0287039. doi:10.1371/journal.pone.0287039

Aniche, L. Q., Edelenbos, J., Gianoli, A., Enseñado, E. M., Makousiari, E., DeLosRíos-White, M. I., ... & Zalokar, S. (2024). Boosting co-creation of Nature-based Solutions within Living Labs: Interrelating enablers using Interpretive Structural Modelling. *Environmental Science & Policy*, *161*, 103873. https://doi.org/10.1016/j.envsci.2024.103873.

Arlati, A., Rödl, A., Kanjaria-Christian, S., & Knieling, J. (2021). Stakeholder participation in the planning and design of nature-based solutions. Insights from CLEVER cities project in Hamburg. *Sustainability*, *13* (5), 2572.

Arnould, M., Morel, L., & Fournier, M. (2022). Embedding non-industrial private forest owners in forest policy and bioeconomy issues using a Living Lab concept. *Forest Policy and Economics*, *139*, 102716.

Arnstein, S. R. (1969). A ladder of citizen participation. Journal of the American Institute of Planners 35/4: 216–224

Bagagnan, A., Ouedraogo, I., Fonta, W. (2019), *Perceived climate variability and farm level adaptation in the central river region of the Gambia*, Atmosphere *10(7)*, 423, https://doi.org/10.3390/atmos10070423

Bagoudou Labo, O., Zhegu, M., & Merveille, N. (2024). Cultivating Sustainability: Quebec's Living Labs as Ecological Catalysts. *Sustainability*, *16* (5), 1887.

Ballon, P., & Schuurman, D. (2015). Living labs: concepts, tools and cases. *info, 17*(4).

Bank Danych Lokalnych (BDL) [Local Data Bank], https://bdl.stat.gov.pl/bdl/dane/teryt/kategoria/284.

Barbieri, L., Bittner, C., Wollenberg, E., Adair, C. (2024), *Climate change adaptation and mitigation in agriculture: a review of the evidence for synergies and tradeoffs*, Environmental Research Lett., 19, 013005

Barraclough, A. D., Reed, M. G., Coetzer, K., Price, M. F., Schultz, L., Moreira-Muñoz, A., & Måren, I. (2023). Global knowledge–action networks at the frontlines of sustainability: Insights from five decades of science for action in UNESCO's World Network of biosphere reserves. *People and Nature*, *5* (5), 1430-1444.

Baškarada, S., Shrimpton, D., Ng, S.(2016). Learning through foresight. Foresight, 18(4), 414-433. DOI: 10.1108/FS-09-2015-0045

Bauchinger, L., Reichenberger, A., Goodwin-Hawkins, B., Kobal, J., Hrabar, M., &Oedl-Wieser, T. (2021). Developing Sustainable and Flexible Rural–Urban Connectivity through Complementary Mobility Services. Sustainability, 13(3), 1280.

Beaudoin, C., Joncoux, S., Jasmin, J.F., Berberi, A., McPhee, C., Schillo., R., Nguyen, V.M. (2022), *A research agenda for evaluating living labs as an open innovation model for environmental and agricultural sustainability*, Environmental Challenges, 7:100505

Belay, A., Oludhe, C., Mirzabaev, A., Recha, J., Berhane, Z., Osano, P., Demissie, T., Olaka, L., Solomon, D. (2022), *Knowledge of climate change and adaptation by smallholder farmers: evidence from southern Ethiopia*, Heliyon, *8*, https://doi.org/10.1016/j.heliyon.2022.e12089

Berberi, A., Beaudoin, C., McPhee, C., Guay, J., Bronson, K., & Nguyen, V. M. (2023). Enablers, barriers, and future considerations for living lab effectiveness in environmental and agricultural sustainability transitions: a review of studies evaluating living labs. *Local Environment*, 1-19.

Beretić, N., Bauer, A., Funaro, M., Spano, D., & Marras, S. (2024). A participatory framework to evaluate coherence between climate change adaptation and sustainable development policies. *Environmental Policy and Governance*, *34* (3), 275-290. https://doi.org/10.1002/eet.2076.

Bergvall-Kåreborn, B., Holst, M., Ståhlbröst, A. (2009). Concept design with a Living Lab approach. Proceedings of the 42nd Hawaii International Conference on System Sciences. DOI: 10.1109/HICSS.2009.123

Białowieski Park Narodowy [Białowieża National Park], https://bpn.com.pl.

Black, D., Charlesworth, S., Dal Poz, M. E., Francisco, E. C., Paytan, A., Roderick, I., ... & Winter, K. (2023). Comparing Societal Impact Planning and Evaluation Approaches across Four Urban Living Labs (in Food-Energy-Water Systems). Sustainability, 15(6), 5387.

BML, B. für L., Regionen und Tourismus. (2022). Richtlinie für die sachgerechte Düngung im Ackerbau und Grünland Anleitung zur Interpretation von Bodenuntersuchungsergebnissen in der Landwirtschaft, 8. Auflage. https://info.bml.gv.at/dam/jcr:67e04ac8-3c5f-4803-bf50-e06c7df2eb24/Richtlinie%20f%C3%BCr%20die%20sachgerechte%20D%C3%BCngung%20im%20Ackerbau%20und%20Gr%C3%BCnland_8%20Auflage%20NEU.pdf.

Bouma, J. (2022). Transforming living labs into lighthouses: a promising policy to achieve land-related sustainable development. *Soil*, *8*(2), 751-759.

Bouma, J. (2023). The 5C's of soil security guiding realization of ecosystem services in line with the UN-SDGs. *Soil Security*, 12, 100099.

Bouma, J., de Haan, J., & Dekkers, M. F. S. (2022). Exploring operational procedures to assess ecosystem services at farm level, including the role of soil health. *Soil Systems*, *6* (2), 34.

Bouwma, I., Wigboldus, S., Potters, J., Selnes, T., van Rooij, S., Westerink, J. (2022), *Sustainability Transitions and the Contribution of Living Labs: A Framework to Assess Collective Capabilities and Contextual Performance*, Sustainability, 14(23), 15628; https://doi.org/10.3390/su142315628

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Brandt, E. (2006). Designing exploratory design games: a framework for participation in participatory design?. In Proceedings of the ninth conference on Participatory design: Expanding boundaries in design-Volume 1 (pp. 57-66).
Brohmer, H., Munz, K., Röderer, K., Anzengruber, C., Wendland, M., & Corcoran, K. (2023). How attractive is the participation in a Living Lab study? Experimental evidence and recommendations. *Discover Sustainability*, *4* (1), 23.
Brons, A., van Der Gaast, K., Awuh, H., Jansma, J. E., Segreto, C., & Wertheim-Heck, S. (2022). A tale of two labs: Rethinking urban living labs for advancing citizen engagement in food system transformations. *Cities*, *123*, 103552., https://doi.org/10.1016/j.cities.2021.103552.
Buchgraber, K. (2018). Zeitgemässe Grünlandbewirtschaftung. Leopold Stocker Verlag.
Busse, M., Zscheischler, J., Zoll, F., Rogga, S., & Siebert, R. (2023). Co-design approaches in land use related sustainability science–A systematic review. *Land Use Policy*, *129*, 106623.
Cai, Y., & Lattu, A. (2022). Triple helix or quadruple helix: which model of innovation to choose for empirical studies?. Minerva, 60(2), 257-280.
Carayannis, E. G., & Campbell, D. F. (2010). Triple Helix, Quadruple Helix and Quintuple Helix and how do knowledge, innovation and the environment relate to each other?: a proposed framework for a trans-disciplinary analysis of sustainable development and social ecology. *International Journal of Social Ecology and Sustainable Development (IJSESD)*, *1* (1), 41-69.
Carayannis, E. G., & Campbell, D. F. (2021). Democracy of climate and climate for democracy: The evolution of quadruple and quintuple helix innovation systems. *Journal of the Knowledge Economy*, 12(4), 2050-2082.
Cascone, G., Scuderi, A., Guarnaccia, P., & Timpanaro, G. (2024). Promoting innovations in agriculture: Living labs in the development of rural areas. *Journal of Cleaner Production*, 141247.
Ceseracciu, C., Branca, G., Deriu, R., & Roggero, P. P. (2023). Using the right words or using the words right? Re-conceptualising living labs for systemic innovation in socio-ecological systems. Journal of Rural Studies, 104, 103154.
Chermack, T. J. (2011). Scenario Planning in Organizations: How to Create, Use and Assess Scenarios. Berrett-Koehler
Christina Lehmann, P. I. 2016. Multiplier-workshop for the MARISCO-method exemplified by the Schorfheide-Chorin Biosphere Reserve, Germany. Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ).
Ciaccia, C., Testani, E., Fiore, A., Iocola, I., Di Pierro, M., Mele, G., ... & Diacono, M. (2021). Organic agroforestry long-term field experiment designing trough actors' knowledge towards food system sustainability. *Sustainability*, *13* (10), 5532.
Ciliberti, S., Bartolini, F., Brunori, A., Mariano, E., Metta, M., Brunori, G., & Frascarelli, A. (2022). EUTR implementation in the Italian wood-energy sector: Role and impact of (ongoing) digitalisation. *Forest Policy and Economics*, *141*, 102758.
Committee, G. M. N. (2005). Full of life: UNESCO biosphere reserves—model regions for sustainable development: Springer.
Compagnucci, L., Spigarelli, F., Coelho, J., & Duarte, C. (2021). Living Labs and user engagement for innovation and sustainability. *Journal of Cleaner Production*, *289*, 125721.
Copernicus, C. L. C. 2012. (o. J.). CORINE Landcover 2012 [Map]. https://land.copernicus.eu/en/products/corine-land-cover/clc-2012.
Cuhls, K. (2003). From Forecasting to Foresight Processes – New Participative Foresight Activities in Germany. Journal of Forecasting 22(2-3), 93-111. DOI: 10.1002/for.848
data.gv.at. (2015). Digitales Geländemodell (DGM) Österreich—Data.gv.at [dataset]. https://www.data.gv.at/katalog/de/dataset/dgm.
data.gv.at. (2023a). Gliederung Österreichs in Gemeinden—Data.gv.at [dataset]. https://www.data.gv.at/katalog/dataset/stat_gliederung-osterreichs-in-gemeinden14f53#resources.
data.gv.at. (2023b). Verwaltungsgrenzen (VGD)—Stichtagsdaten grundstücksgenau—Data.gv.at [dataset]. https://www.data.gv.at/katalog/dataset/51bdc6dc-25ae-41de-b8f3-938f9056af62#resources
Davidson, S. 1998. Spinning the wheel of empowerment. Planning 3: 14 –15.
DEIMS-SDR. (2023, Juli 21). LTSER Platform Eisenwurzen (EW)—Austria. https://deims.org/d0a8da18-0881-4ebe-bccf-bc4cb4e25701
Delina, L., (2020), *Potentials and critiques of building a Southeast Asian interdisciplinary knowledge community on critical geoengineering studies*, Clim. Change, 163 (2) (2020), pp. 973-987
Dell'Era, C., & Landoni, P. (2014). Living Lab: A methodology between user-centred design and participatory design. Creativity and Innovation Management, 23(2), 137-154.
Dell'Era, C., Landoni, P., & Gonzalez, S. J. (2019). Investigating the innovation impacts of user-centred and participatory strategies adopted by European Living Labs. *International Journal of Innovation Management*, *23* (05), 1950048.
DeLosRíos-White, M. I., Roebeling, P., Valente, S., & Vaittinen, I. (2020). Mapping the life cycle co-creation process of nature-based solutions for urban climate change adaptation. *Resources*, *9* (4), 39.
Dogan, E., Cuomo, F., & Battisti, L. (2023). Reviving urban greening in post-industrial landscapes: The case of Turin. *Sustainability*, *15* (17), 12760.
Dupont, L., Jacob, S, Philippe, H. (2024), *Scientist engagements and the knowledge-action gap*, Nature, Ecology & Evolution, Springer, DOI: 10.1038/s41559-024-02535-0
Dutilleul, B., Birrer, F. A., & Mensink, W. (2010). Unpacking European Living Labs: Analysing innovation's social dimensions. Central European journal of public policy, 4(1).
Eriksson, M., Niitamo, V. P., Kulkki, S., & Hribernik, K. A. (2006). Living labs as a multi-contextual R&D methodology. In 2006 IEEE International Technology Management Conference (ICE) (pp. 1-8)
Eriksson, M., Niitamo, V.P., Kulkki, S., 2005. State-of-the-art in Utilizing Living Labs Approach to User-centric ICT Innovation-a European Approach. Lulea: Center for Distance-spanning Technology. Lulea University of Technology, Sweden: Lulea.
Fèche, R., Noûs, C., & Barataud, F. (2021). Building a transformative initiative for a territorialized agri-food system: constructing a living-lab and confronting norms? A case study from Mirecourt (Vosges, France). *Journal of Rural Studies*, *88*, 400-409, https://doi.org/10.1016/j.jrurstud.2021.07.026.
Følstad, A. (2008). Living labs for innovation and development of information and communication technology: a literature review. The Electronic Journal for Virtual Organizations and Networks, Volume 10, "Special Issue on Living Labs".

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Funded by the European Union (10108307). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EC-CINEA. Neither the European Union nor the granting authority can be held responsible for them.

Frazier, T., Wood, N., Yarnal, B. (2010), *Stakeholder perspectives on land-use strategies for adapting to climate-change-enhanced coastal hazards: Sarasota, Florida, Applied Geography, 30(4):* 506-517
Gamache, G., Anglade, J., Feche, R., Barataud, F., Mignolet, C., &Coquil, X. (2020). Can living labs offer a pathway to support local agri-food sustainability transitions?. Environmental Innovation and Societal Transitions, 37, 93-107.
García-Llorente, M., Pérez-Ramírez, I., Sabán de la Portilla, C., Haro, C., & Benito, A. (2019). Agroecological strategies for reactivating the agrarian sector: the case of Agrolab in Madrid. *Sustainability*, *11* (4), 1181. https://doi.org/10.3390/su11041181.
Gardezi, M., Abuayyash, H., Adler, P., Alvez, J., Anjuml, R., Badireddy, A., Brugler, S., Carcamo, P., Clay, D., Dadkhah, A., Emery, M., Faulkner, J., Joshi, B., Joshi, D., Khan, A., Koliba, C., Kumari, S., McMaine, J., Merrill, S., Mitra, S., Musayev, S., Oikonomou, P., Pinder, G., Prutzer, E., Rathore, J., Ricketts, T., , Rizzo, D., Ryan, B., Sahraei, M., Schroth, A., Turnbull , S., Zia, A. (2024), *The role of living labs in cultivating inclusive and responsible innovation in precision agriculture*, Agricultural Systems, 216, 103908
GeDaBa, G. (2022a, August 5). BAB-Datenpool: Agrarstrukturerhebung. https://gedaba.agrarforschung.at/home.
GeDaBa, G. (2022b, August 5). BAB-Datenpool: Fläche nach Betriebssitz und Früchten. https://gedaba.agrarforschung.at/home.
GeDaBa, G. (2022c, August 5). BAB-Datenpool: Flächen nach Betriebssitz. https://gedaba.agrarforschung.at/home.
GeDaBa, G. (2022d, August 5). BAB-Datenpool: GVE. https://gedaba.agrarforschung.at/home.
GeDaBa, G. (2022e, August 5). BAB-Datenpool: InVeKOS. https://gedaba.agrarforschung.at/home.
GeoSphere Austria. (2023). Klimakarten [dataset]. https://www.data.gv.at/katalog/dataset/51bdc6dc-25ae-41de-b8f3-938f9056af62#resources.
Greve, K., Leminen, S., De Vita, R., & Westerlund, M. (2020). Unveiling the diversity of scholarly debate on living labs: A bibliometric approach. International Journal of Innovation Management, 24(08), 2040003.
Griffiths, P., C. Nendel, J. Pickert & P. Hostert (2020) Towards national-scale characterization of grassland use intensity from integrated Sentinel-2 and Landsat time series. *Remote Sensing of Environment,* 238**,** 111124.
Grigorieva, E., Livenets, A., Stelmakh, E. (2023), *Adaptation of Agriculture to Climate Change: A Scoping Review*, Climate, *11*: 202, https://doi.org/10.3390/cli11100202
Gutiérrez-Briceño, I., García-Llorente, M., Turkelboom, F., Mortelmans, D., Defrijn, S., Yacamán-Ochoa, C., ... & Siegert, A. (2024). Towards sustainable landscapes: Implementing participatory approaches in contract design for biodiversity preservation and ecosystem services in Europe. *Environmental Science & Policy*, *160*, 103831. DOI: 10.1016/j.envsci.2024.103831.
Higgins, A., & Klein, S. (2011). Introduction to the living lab approach. Accelerating Global Supply Chains with IT-Innovation: ITAIDE tools and methods, 31-36.
Hoegh-Guldberg, O., Jacob, D., Taylor, M. (2018), *Impacts of 1.5°C of Global Warming on Natural and Human Systems* In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I.Gomis, E. Lonnoy, T.Maycock, M.Tignor, and T. Waterfield (eds.)]
Holtgrave, A.-K., F. Lobert, S. Erasmi, N. Röder & B. Kleinschmit (2023) Grassland mowing event detection using combined optical, SAR, and weather time series. *Remote Sensing of Environment,* 295**,** 113680.
Hossain, M., Leminen, S., & Westerlund, M. (2019). A systematic review of living lab literature. *Journal of cleaner production*, *213*, 976-988. https://doi.org/10.1016/j.jclepro.2018.12.257.
Hüllbusch, E., Brandt, L. M., Ende, P., & Dengler, J. (2016). Little vegetation change during two decades in a dry grassland complex in the Biosphere Reserve Schorfheide-Chorin (NE Germany). Tuexenia (No.36), 395-412.
Hurlbert, M., & Gupta, J. (2015). The split ladder of participation: A diagnostic, strategic, and evaluation tool to assess when participation is necessary. Environmental Science & Policy, 50, 100-113.
Hurlbert, M., & Gupta, J. (2024). The split ladder of participation: A literature review and dynamic path forward. Environmental Science & Policy, 157, 103773.
Hvitsand, C., Raanaas, R. K., Gjøtterud, S., & Nicolaysen, A. M. (2022). Establishing an Agri-food living lab for sustainability transitions: Methodological insight from a case of strengthening the niche of organic vegetables in the Vestfold region in Norway. *Agricultural systems*, *199*, 103403.
Immaterielles UNESCO Kulturerbe. (2023, November 9). Verein Eisenstrasse. http://www.eisenstrasse.co.at/bergmaennische-tradition/immaterielles-unesco-kulturerbe/.
Inayatullah, S. (2008). Six pillars: Futures thinking for transforming. foresight 10(1). DOI: 10.1108/14636680810855991
IPCC (2021), *Climate Change Workshop Report, Biodiversity and Climate Change, IPCC*
Jarzebski, M. P., Su, J., Abrahamyan, A., Lee, J., Kawasaki, J., Chen, B., ... & Gasparatos, A. (2023). Developing biodiversity-based solutions for sustainable food systems through transdisciplinary Sustainable Development Goals Labs (SDG-Labs). *Frontiers in Sustainable Food Systems*, *7*, 1144506.
Jonasz, G., & Varga, K. (2022). Organic living labs and lighthouse farms in Europe, Brussels, 2022 https://orgprints.org/id/eprint/46117/1/TPO_Study_Organic_Living_Labs_2022.pdf
Kalinauskaite, I., Brankaert, R., Lu, Y., Bekker, T., Brombacher, A., & Vos, S. (2021). Facing societal challenges in living labs: Towards a conceptual framework to facilitate transdisciplinary collaborations. *Sustainability*, *13* (2), 614.
Kalsnes, B., Oen, A., Frauenfelder, R., Heggelund, I., Vasbotten, M., Vollstedt, B, Koerth J., Vafeidis N., van Well L., Jan Ellen G., Koers G. & Raaphorst, K. (2023). Stakeholder evaluation of the co-production process of climate services. Experiences from two case studies in Larvik (Norway) and Flensburg (Germany). *Climate Services*, *32*, 100409.
Kazadi, K., Lievens, A., & Mahr, D. (2016). Stakeholder co-creation during the innovation process: Identifying capabilities for knowledge creation among multiple stakeholders. Journal of Business Research, 69(2), 525-540. https://doi.org/10.1016/j.jbusres.2015.05.009
Kiryluk H., *Forest resources as a basis to creation of an integrated tourist product of an area on the example of Białowieza forest*, „Economics and Environment" 2016, 4 (59), pp. 307-317, https://ekonomiaisrodowisko.pl/journal/article/view/220/214.

Funded by the European Union

Funded by the European Union (10108307). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EC-CINEA. Neither the European Union nor the granting authority can be held responsible for them.

Knutti, R. (2019), *Closing the Knowledge-Action Gap in Climate Change*, One Earth, *1 (1)*, Elsevier Inc.
Kobzeva, M., &Knickel, K. (2018). Instead of just Talking We Are actually Doing It!. Initial In-sights into the Use of Living Labs in the EU-funded ROBUST Project.
Kofler, I. (2023). Beyond disciplinary constraints: designing transdisciplinary research and collaboration in real-world laboratories. Societies, 13(9), 205.
Laborgne, P., Ekille, E., Wendel, J., Pierce, A., Heyder, M., Suchomska, J., ... & Goszczynski, W. (2021). Urban Living Labs: how to enable inclusive transdisciplinary research?. Urban transformations, 3, 1-18.
Leminen, S. (2013) Coordination and Participation in Living Lab Networks, Technology Innovation Management Review, 3(11): 5-14.
Leminen, S., Nyström, A. G., & Westerlund, M. (2015). A typology of creative consumers in living labs. Journal of Engineering and Technology Management, 37, 6-20.
Leminen, S., Westerlund, M., & Nyström, A.-G. (2012). Living Labs as Open-Innovation Networks, Technology Innovation Management Review, 2(9): 6-11.
Lianu, C., Radulescu, I. G., &Lianu, C. (2024). New Business Models in Agroecology: Study Case-Innovation Hub Bio Danubius as Private (Voluntary) Standards Based on Indicators. Annals of Spiru Haret University. Economic Series, 24(1).
Lianu, C., Simion, V. E., Urdes, L., Bucea-Manea-Țoniș, R., Radulescu, I. G., &Lianu, C. (2023). Agroecological Approaches in the Context of Innovation Hubs. Sustainability, 15(5), 4335.
Lynch, J., Cain, M., Frame, D., & Pierrehumbert, R. (2021). Agriculture's contribution to climate change and role in mitigation is distinct from predominantly fossil CO2-emitting sectors. *Frontiers in sustainable food systems*, 4, 518039.
Löbmann, M. T., Maring, L., Prokop, G., Brils, J., Bender, J., Bispo, A., & Helming, K. (2022). Systems knowledge for sustainable soil and land management. *Science of The Total Environment*, *822*, 153389.
Loboguerrero, A.M., Campbell, B., Cooper, P., Hansen, J., Rosenstock, T., Wollenberg, E. (2019), *Food and Earth Systems: Priorities for Climate Change Adaptation and Mitigation for Agriculture and Food Systems*, Sustainability, *11*: 1372, doi:10.3390/su11051372
LTSER Platform Eisenwurzen (Regisseur). (2023). Landscape photograph. https://www.lter-austria.at/ltser-plattform-eisenwurzen-ew/.
Luján Soto, R., Cuéllar-Padilla, M., Rivera Méndez, M., Pinto-Correia, T., Boix-Fayos, C., & de Vente, J. (2021). Participatory monitoring and evaluation to enable social learning, adoption, and out-scaling of regenerative agriculture.
Lupp, G., Huang, J. J., Zingraff-Hamed, A., Oen, A., Del Sepia, N., Martinelli, A, Lucchesi, M., Knutsen, TW., Olsen, M., Fjosne, TF., Balaguer, EM., Arauzo, I., Solheim, A., Kalsnes, B. & Pauleit, S. (2021). Stakeholder perceptions of nature-based solutions and their collaborative co-design and implementation processes in rural mountain areas—a case study from PHUSICOS. *Frontiers in Environmental Science*, *9*, 678446.
Lupp, G., Zingraff-Hamed, A., Huang, J. J., Oen, A., & Pauleit, S. (2020). Living labs—a concept for co-designing nature-based solutions. *Sustainability*, *13* (1), 188.
Macintyre, T., Monroy, T., Coral, D., Zethelius, M., Tassone, V., & Wals, A. E. (2019). T-labs and climate change narratives: Co-researcher qualities in transgressive action–research. *Action Research*, *17* (1), 63-86.
Madaki, M., Muench, S., Kaechele, H., Bavorova, M. (2023), *Climate change knowledge and perception among farming households in Nigeria*, Climate, *11*: 115, https://doi.org/10.3390/cli11060115
Mahmoud, I. H., Morello, E., Vona, C., Benciolini, M., Sejdullahu, I., Trentin, M., & Pascual, K. H. (2021). Setting the social monitoring framework for nature-based solutions impact: Methodological approach and pre-greening measurements in the case study from CLEVER cities Milan. *Sustainability*, *13* (17), 9672.
Malik, I.H., Ford, J. (2024), *Addressing the Climate Change Adaptation Gap: Key Themes and Future Directions*, Climate 12(24), https://doi.org/10.3390/cli12020024
Mambrini-Doudet, M., Gascuel, C., Göldel, B., McKhann, H. (2021). D1.1 Reference document with key concepts: Vision for building the network of living labs and research infrastructures for agroecology transition. ALL-Ready Deliverable.
Marselis, S. M., Hannula, S. E., Trimbos, K. B., Berg, M. P., Bodelier, P. L., Declerck, S. A., ... & Schrama, M. (2024). The use of living labs to advance agro-ecological theory in the transition towards sustainable land use: A tale of two polders. *Environmental Impact Assessment Review*, *108*, 107588.
Massari, S., Galli, F., Mattioni, D., & Chiffoleau, Y. (2023). Co-creativity in living labs: Fostering creativity in co-creation processes to transform food systems. *JCOM: JOURNAL OF SCIENCE COMMUNICATIONS*, *22*(3). DOI: 10.22323/2.22030203
Mbatha, S. P., &Musango, J. K. (2022). A systematic review on the application of the living lab concept and role of stakeholders in the energy sector. Sustainability, 14(21), 14009.
McCrory, G., Schäpke, N., Holmén, J., & Holmberg, J. (2020). Sustainability-oriented labs in real-world contexts: An exploratory review. *Journal of Cleaner Production*, *277*, 123202.
McPhee, C., Bancerz, M., Mambrini-Doudet, M., Chrétien, F., Huyghe, C., & Gracia-Garza, J. (2021). The defining characteristics of agroecosystem living labs. *Sustainability*, *13* (4), 1718.
Mechler, R., Singh, C., Ebi, K.., Djalante, R., Thomas, A., James, R., Tschakert, P., Wewerinke-Singh, M., Schinko, T., Ley, D., *Loss and Damage and limits to adaptation: Recent IPCC insights and implications for climate science and policy,* Sustain. Sci. 2020, 15, 1245–1251
Menny, M., Palgan, Y. V., & McCormick, K. (2018). Urban living labs and the role of users in co-creation. *GAIA-Ecological Perspectives for Science and Society*, *27* (1), 68-77.
Merino-Barbancho, B., Abril Jiménez, P., Mallo, I., Lombroni, I., Cea, G., López Nebreda, C., ... & Arredondo, M. T. (2023). Innovation through the Quintuple Helix in living labs: lessons learned for a transformation from lab to ecosystem. Frontiers in Public Health, 11, 1176598.
Metta, M., Ciliberti, S., Obi, C., Bartolini, F., Klerkx, L., & Brunori, G. (2022). An integrated socio-cyber-physical system framework to assess responsible digitalisation in agriculture: A first application with Living Labs in Europe. *Agricultural Systems*, *203*, 103533. https://doi.org/10.1016/j.agsy.2022.103533.
Meyer-Aurich, A., Zander, P., & Hermann, M. (2003). Consideration of biotic nature conservation targets in agricultural land use—a case study from the Biosphere Reserve Schorfheide-Chorin. *Agriculture, Ecosystems & Environment, 98* (1), 529-539. doi: https://doi.org/10.1016/S0167-8809(03)00111-7.

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Funded by the European Union (10108307). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EC-CINEA. Neither the European Union nor the granting authority can be held responsible for them.

Meyfroidt, P., Chowdhury, R. R., de Bremond, A., Ellis, E. C., Erb, K. H., Filatova, T., ... & Verburg, P. H. (2018). Middle-range theories of land system change. Global environmental change, 53, 52-67.
Mitić-Radulović, A., & Lalović, K. (2021). Multi-level perspective on sustainability transition towards nature-based solutions and co-creation in urban planning of Belgrade, Serbia. *Sustainability*, *13* (14), 7576.
Moeskops Bram, Gernert Maria (Eds.) (2022), Organic Living Labs & Lighthouse Farms in Europe, TP Organics, Brussels, 2022
Mooney, M., Middlecamp, C., Martin, J., Ackerman, S. (2022), *The demise of the knowledge-action gap in climate change education*, American Meteorological Society, https://doi.org/10.1175/BAMS-D-21-0256.1
Moreira, F. D. A., Dalla Fontana, M., Sepe, P. M., Lopes, M. V., Moura, L. D. V., Medeiros, L. S., ... & Di Giulio, G. M. (2022). Co-creating sustainability indicators for the local water–energy–food nexus. *Sustainability Science*, *17* (6), 2315-2329.
Moruzzo, R., Espinosa Diaz, S., Granai, G., Di Iacovo, F., & Riccioli, F. (2024). Living lab as support for co-creation of value: application to agro-biodiversity contracting solutions. Local Environment, 1-14.
Naustdalslid, J. (2011), *Climate change – the challenge of translating scientific knowledge into action*, International Journal of Sustainable Development & World Ecology, 18 (3), 243-252, DOI: 10.1080/13504509.2011.572303
Nevmerzhitskaya, J., Santonen, T., &Purola, A. (2019). Living Labs: from abstraction to implementation. Case CIRC4LIFE Living Labs. Laurea Journal. Retrieved from https://journal. laurea. fi/living-labs-from-abstraction-to-implementation-case-circ4life-living-labs.
Nguyen, H. T., & Marques, P. (2022). The promise of living labs to the Quadruple Helix stakeholders: Exploring the sources of (dis) satisfaction. *European Planning Studies*, *30* (6), 1124-1143.
Noble, K., & Enseñado, E. M. (2022). Analyzing co-creation levels of urban living labs in Europe. https://doi.org/10.13135/2384-8677/7060.
Oedl-Wieser, T., Hausegger-Nestelberger, K., Dax, T., &Bauchinger, L. (2020). Formal and informal governance arrangements to boost sustainable and inclusive rural-urban synergies: An analysis of the metropolitan area of styria. Sustainability, 12(24), 10637.
Ostermann-Miyashita, E. F., König, H. J., Pernat, N., Bellingrath-Kimura, S. D., Hibler, S., & Kiffner, C. (2022). Knowledge of returning wildlife species and willingness to participate in citizen science projects among wildlife park visitors in Germany. *People and Nature, 4* (5), 1201-1215.
Palermo, V. Hernandez, Y. (2020), *Group discussions on how to implement a participatory process in climate adaptation planning: a case study in Malaysia*, Ecol. Econ., 177:106791, doi: 10.1016/j.ecolecon.2020.106791
Peña-Torres, J. A., & Reina-Rozo, J. D. (2022). Agroecology and communal innovation: LabCampesino, a pedagogical experience from the rural youth in Sumapaz Colombia. *Current Research in Environmental Sustainability*, *4*, 100162. https://doi.org/10.1016/j.crsust.2022.100162.
Pereira, L. M., Kushitor, S. B., Cramer, C., Drimie, S., Isaacs, M., Malgas, R., ... & Willis, J. (2022). Leveraging the potential of wild food for healthy, sustainable, and equitable local food systems: learning from a transformation lab in the Western Cape region. Sustainability Science, 1-20.
Pertry, I., Bleyaert, P., Demyttenaere, P., & Demeulemeester, M. (2017, September). Agrotopia, a living lab for high-tech urban horticulture within Europe. In *International Symposium on Greener Cities for More Efficient Ecosystem Services in a Climate Changing World 1215* (pp. 153-158). DOI: 10.17660/ActaHortic.2018.1215.29.
Plassnig, S. N., Pettit, M., Reichborn-Kjennerud, K., & Säumel, I. (2022). Successful scaling of Edible City Solutions to promote food citizenship and sustainability in food system transitions. *Frontiers in Sustainable Cities*, *4*, 1032836.
Ponadlokalna strategia rozwoju Gmin Powiatu Hajnowskiego i Powiatu Hajnowskiego na lata 2022-2030 [Supralocal Development Strategy of the Communes of Hajnówka District and Hajnówka District for 2022-2030], Pheno Horizon OLP Sp. z o.o., Hajnówka- Łódź 2023.
Ponce, A.M., Corona-Núnez, R., Nava, L.F., Estrada, F., Calderón-Bustamante, O., Martínez-Meyer, Carabias, J., Larralde-Corona, A., Barrios, M., Pardo-Villegas, P. (2021), Impacts of land management and climate change in a developing and socioenvironmental challenging transboundary region, Journal of Environmental Management, 300: 113748
Popper, R. (2008). How are foresight methods selected?. Foresight, 10(6), 62-89. DOI: 10.1108/14636680810918586
Potters, J., Collins, K., Schoorlemmer, H., Stræte, E. P., Kilis, E., Lane, A., & Leloup, H. (2022). Living Labs as an Approach to Strengthen Agricultural Knowledge and Innovation Systems. EuroChoices, 21(1), 23-29.
Poudel, M., Rana, E., Poudyal, B. (2022), *Climate Change and Community Forestry in Nepal*, In book: Revitalizing Community Forestry in the Changing Socioeconomic Context in Nepal. (pp.86)Publisher: Forest Action
Regionalna Dyrekcja Lasów Państwowych w Białymstoku [Regional Directorate of State Forests in Białystok], 2023, https://www.bialystok.lasy.gov.pl/lesny-kompleks-promocyjny-puszcza-bialowieska-.
Ricart, S., Gandolfi, C., Castelletti, A. (2023), *Climate change awareness, perceived impacts, and adaptation from farmers' experience and behavior: a triple-loop review*, Regional Environmental Change, 23:82, https://doi.org/10.1007/s10113-023-02078-3
Roche, D.G., O'Dea, R.E., Kerr, K.A., Rytwinski, T., Schuster, R., Nguyen, V., Young, N., Bennett, J., Cooke, S. (2021), *Closing the knowledge-action gap in conservation with open science*, Conservation Biology, 36, https://doi.org/10.1111/cobi.13835
Roggema, R., & Yan, W. (2019). Developing a design-led approach for the food-energy-water nexus in cities. *Urban planning*, *4* (1), 123-138.
Ruijsink, S., Smith, A. (2016) Transformative Social Innovation: European Network of Living Labs: summary report. TRANSIT: EU SSH.2013.3.2-1 Grant agreement no: 613169
Salembier, C., Aare, A. K., Bedoussac, L., Chongtham, I. R., de Buck, A., Dhamala, N. R., ... & Jeuffroy, M. H. (2023). Exploring the inner workings of design-support experiments: Lessons from 11 multi-actor experimental networks for intercrop design. *European Journal of Agronomy*, *144*, 126729.
Sanders, E. B. N., &Stappers, P. J. (2008). Co-creation and the new landscapes of design. Co-design, 4(1), 5-18.
Sarabi, S., Han, Q., L. Romme, A. G., de Vries, B., Valkenburg, R., den Ouden, E., ... & Wendling, L. (2021). Barriers to the adoption of urban living labs for NBS implementation: a systemic perspective. *Sustainability*, *13* (23), 13276, https://doi.org/10.3390/su132313276.
Schaefer, E., Scheele, U. (2014), *Bridging the transformation gap with living labs ? Paper presented at the Urban Regions under Change: towards social-ecological resilience* (URC 2014), Hamburg, Germany
Schaffers, H., Merz, C., Guzman, J.G., Navarro, M. (2009). Living labs and rural development: overview of the C@R project. The Electronic Journal for Virtual Organizations and Networks, 11(1-8).

Funded by the European Union

Funded by the European Union (10108307). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or EC-CINEA. Neither the European Union nor the granting authority can be held responsible for them.

Schäpke, N., Stelzer, F., Caniglia, G., Bergmann, M., Wanner, M., Singer-Brodowski, M., ... & Lang, D. J. (2018). Jointly experimenting for transformation? Shaping real-world laboratories by comparing them. GAIA-Ecological Perspectives for Science and Society, 27(1), 85-96.
Schorfheide-Chorin Biosphere Reserve: https://www.schorfheide-chorin-biosphaerenreservat.de/en/.
Schuurman, D., De Marez, L., & Ballon, P. (2015). Living Labs: a systematic literature review. Open Living Lab Days 2015.
Sieber, R., Faulenbach, L., Fuchs, M., & Gülleken, L. (2022). The challenges of co-research in labs in real-world contexts: Empirical findings from four labs in the context of urban climate-change research. *Town Planning Review*, *93* (2), 139-163.
Snep, R. P., Klostermann, J., Lehner, M., & Weppelman, I. (2023). Social housing as focus area for Nature-based Solutions to strengthen urban resilience and justice: Lessons from practice in the Netherlands. *Environmental Science & Policy*, *145*, 164-174.
Socher, S. A., Prati, D., Boch, S., Müller, J., Klaus, V. H., Hölzel, N., & Fischer, M. (2012). Direct and productivity-mediated indirect effects of fertilization, mowing and grazing on grassland species richness. *Journal of Ecology*, *100* (6), 1391-1399, https://doi.org/10.1111/j.1365-2745.2012.02020.x
Soini, K., Anderson, C. C., Polderman, A., Teresa, C., Sisay, D., Kumar, P., ... & Tuomenvirta, H. (2023). Context matters: Co-creating nature-based solutions in rural living labs. *Land Use Policy*, *133*, 106839.
Soto, R. L., de Vente, J., & Padilla, M. C. (2021). Learning from farmers' experiences with participatory monitoring and evaluation of regenerative agriculture based on visual soil assessment. *Journal of Rural Studies*, *88*, 192-204.
Ståhlbröst, A., & Holst, M. (2017). Reflecting on actions in living lab research. Technology Innovation Management Review, 7(2), 27-34.
Statistical Office in Białystok, *Environmental protection and forestry in Podlaskie Voivodship in 2022. Statistical information*, Białystok 2023.
Statistik Austria. (2023). Bevölkerung zu Jahres-/Quartalsanfang [dataset]. https://www.statistik.at/statistiken/bevoelkerung-und-soziales/bevoelkerung/bevoelkerungsstand/bevoelkerung-zu-jahres-/-quartalsanfangStieber, J., & Oberösterreichische Landesausstellung, H. ua. (1998). Land der Hämmer: Heimat Eisenwurzen ; [Region Pyhrn-Eisenwurzen ; Katalog der Oberösterreichischen Landesausstellung 1998] (1. Aufl..). Residenz-Verl.
Sujakhu, NM., Ranjitkar, .S, Yang, H., Su, Y., Xu, J. (2020) *Quantifying farmers' climate change adaptation strategies and the strategy determinants in Southwest China,* Int J Clim Chang Str 12(4):511–532, https://doi.org/10.1108/IJCCSM-12-2019-0073
Täumer, J., Kolb, S., Boeddinghaus, R. S., Wang, H., Schöning, I., Schrumpf, M., . . . Marhan, S. (2021). Divergent drivers of the microbial methane sink in temperate forest and grassland soils. *Global Change Biology, 27* (4), 929-940.
Thangrak, V., Somboonsuke, B., Sdoodee, S., Darnsawasdi, R., Voe, P. (2020), The smallholder farmers' perceptions of climate variability impact on rice production and the case of adaptation strategies in Banteay Meanchey, (BMC). Cambodia Int J Agric Tech, 16(2):505–516
Thomas, A., Theokritoff, E., Lesnikowski, A., Reckien, D., Jagannathan, K., Cremades, R., Campbell, D., Joe, E.T., Sitati, A., Singh, C. (2021), *Global evidence of constraints and limits to human adaptation,* Reg. Environ. Chang. *21*:85
Tirziu, A., & Vrabie, C. (2017). Living labs–instruments of social innovation in rural areas. Proceedings of the Central and Eastern European e| Dem and e| Gov (CEEEGov) Days.
Toffolini, Q., Capitaine, M., Hannachi, M., & Cerf, M. (2021). Implementing agricultural living labs that renew actors' roles within existing innovation systems: A case study in France. *Journal of Rural Studies*, *88*, 157-168.
Toffolini, Q., Hannachi, M., Capitaine, M., & Cerf, M. (2023). Ideal-types of experimentation practices in agricultural Living Labs: Various appropriations of an open innovation model. *Agricultural Systems*, *208*, 103661.
Tranchina, M., Burgess, P., Cella, F. G., Cumplido-Marin, L., Gosme, M., den Herder, M., ... &Mantino, A. (2024). Exploring agroforestry limiting factors and digitalization perspectives: insights from a european multi-actor appraisal. Agroforestry Systems, 1-17.
UNEP (2023), Adaptation Gap Report, UN Environment Programme (UNEP), *UN Climate Report*
UNESCO World Heritage Convention, https://whc.unesco.org/en/documents/132364.
Van Geenhuizen, M. (2018). A framework for the evaluation of living labs as boundary spanners in innovation. *Environment and Planning C: Politics and Space*, *36* (7), 1280-1298. https://doi.org/10.1177/2399654417753623.
van Valkengoed, A.M., Perlaviciute, G., Steg, L. (2024), *From believing in climate change to adapting to climate change: The role of risk perception and efficacy beliefs*, Risk Analysis, *44*: 553-565
van Valkengoed, A.M., Steg, L. (2019), *Meta-analyses of factors motivating climate change adaptation behaviour*, Nature Climate Change, *9*: 158-163
Verloop, C.M., Wolfert, J., Beulens, A.J.M. (2009). Living Lab "Information Management in Agri-FoodSupply Chain Networks". In: Cunningham, P., Cunningham, M. (Eds.), eChallenges e-2009Conference Proceedings. IIMC International Information Management Corporation Ltd 2009, Istanbul, Turkey
Vicente-Vicente, J. L., Borderieux, J., Martens, K., González-Rosado, M., & Walthall, B. (2023). Scaling agroecology for food system transformation in metropolitan areas: Agroecological characterization and role of knowledge in community-supported agriculture farms connected to a food hub in Berlin, Germany. *Agroecology and Sustainable Food Systems*, *47* (6), 857-889.
Vișinescu, I., Bularda, M., (2008), *Modificări severe în regimul hidrologic al Dunării și impactul acestora asupra agriculturii*, Analele Institutului Național de Cercetare și Dezvoltare în Agricultură – Fundulea, 76, 101-112.
Vyas, S., Khatri-Chhetri, A., Aggarwal, P., Thornton, P., Campbell, B. (2022), *Perspective: The gap between intent and climate action in agriculture*, Global Food Security, 32, 100612
Wakatsuki, H., Ju, H., Nelson, G., Farrell, A., Deryng, D., Meza, F., Hasegawa, T. (2023), *research trends and gaps in climate change impacts and adaptation potentials in major crops*, Current Opinion in Environmental Sustainability, *60*, https://doi.org/10.1016/j.cosust.2022.101249
West, S., van Kerkhoff, L., Wagenaar, H. (2019), *Beyond "linking knowledge and action": towards a practice-based approach to transdisciplinary sustainability interventions*, Policy Studies, 40:5, 534-555, DOI:10.1080/01442872.2019.1618810
Westerlund, M., &Leminen, S. (2011). Managing the challenges of becoming an open innovation company: experiences from Living Labs. Technology Innovation Management Review, 1(1).
Westerlund, M., Leminen, S., & Habib, C. (2018a). Key constructs and a definition of living labs as innovation platforms. Technology Innovation Management Review, 8(12).

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Westerlund, M., Leminen, S., &Rajahonka, M. (2018b). A topic modelling analysis of living labs research. Technology Innovation Management Review, 8(7), 40-51.
Wickenberg, B., Kiss, B., McCormick, K., & Palgan, Y.V. (2022). Seeds of transformative learning: Investigating past experiences from implementing nature-based solutions. *Frontiers in Sustainable Cities*, *4*, 835511.
Willis, K., & Gupta, A. (2023). Place-keeping in the park: Testing a living lab approach to facilitate nature connectedness in urban greenspaces. *Sustainability*, *15* (13), 9930.
Wolfert, J., Verdouw, C. N., Verloop, C. M., & Beulens, A. J. M. (2010). Organizing information integration in agri-food—A method based on a service-oriented architecture and living lab approach. Computers and electronics in agriculture, 70(2), 389-405.
Yahya, F., El Samrani, A., Khalil, M., Abdin, A. E. D., El-Kholy, R., Embaby, M., ... & Takavakoglou, V. (2023). Decentralized Wetland-Aquaponics Addressing Environmental Degradation and Food Security Challenges in Disadvantaged Rural Areas: A Nature-Based Solution Driven by Mediterranean Living Labs. *Sustainability*, *15*(20), 15024. https://doi.org/10.3390/su152015024.
Zavratnik, V., Superina, A., &Stojmenova Duh, E. (2019). Living Labs for rural areas: Contextualization of Living Lab frameworks, concepts and practices. Sustainability, 11(14), 3797.
Zhang, C., Jin, J., Kuang, F., Ning, J., Wan, X., Guan, T. (2020), *Farmers' perceptions of climate change and adaptation behavior in Wushen Banner, China*, Environ. Sci. Pollut. Res., 27 (21), pp. 26484-26494, 10.1007/s11356-020-09048-w
Zingraff-Hamed, A., Hüesker, F., Lupp, G., Begg, C., Huang, J., & Oen, A. (2020). Stakeholder Mapping to Co-Create Nature-Based Solutions: Who Is on Board? *Sustainability. 2020; 12: 8625*.

Funded by the European Union

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Annex 1. Countries' reports of the Mirror Workshops

AUSTRIA

Partner organization: Institute of Social Ecology, BOKU University

Workshop name: Nachhaltige landnutzung - aktuelle und zukünftige herausforderungen (Sustainable land use - current and future challenges)
Date: WS1: October 14th, 2024; WS2: November 18th, 2024
Format: online for both workshops
No of participants: WS1: 6; WS2: 4-5
Participant institutions/organizations: - environmental agency, ministry for climate action, academia, NGO
- ministry for agriculture, federal forestry office, agency for health and food safety, industry, NGO

Country profile

Land sustainability challenges

Q1: Which are the most important land-related sustainability challenges in Austria?

Figure 1: word cloud results for Q1 from the 1st workshop on October 14th

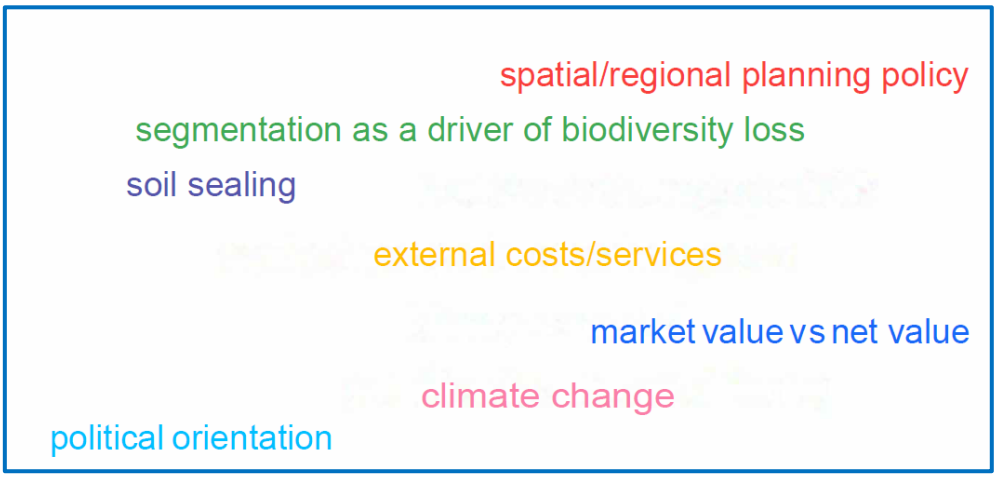


Figure 2: word cloud results for Q1 from the 2nd workshop on November 18th

Factors ranking

Q: Please rank the main factors contributing to changes in land use in Austria

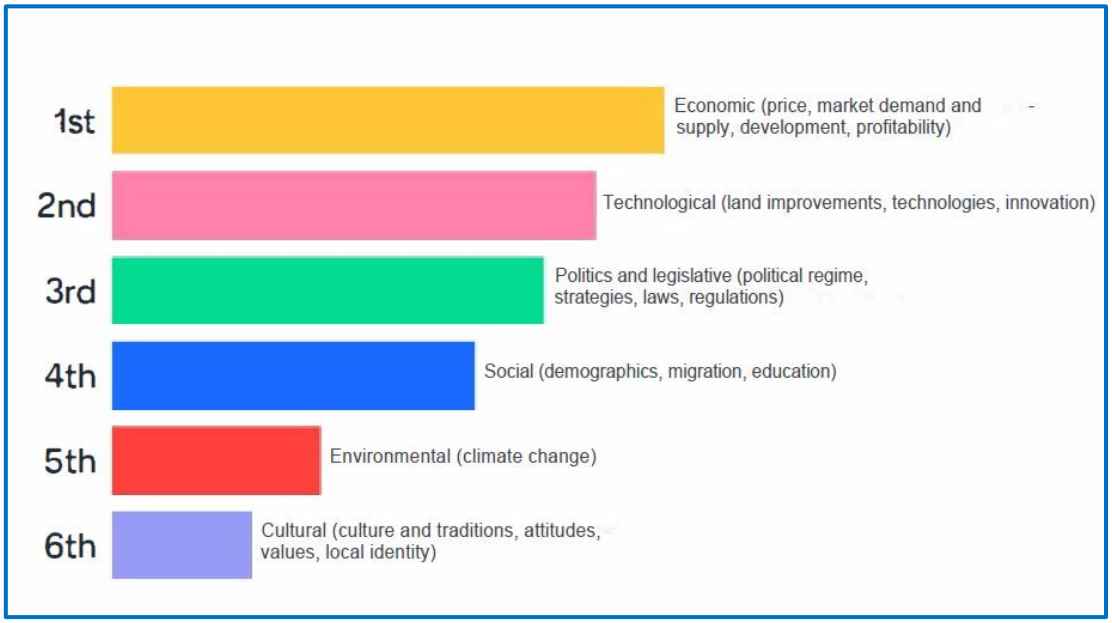


Figure 3: factor ranking results from the 1st workshop on October 14th

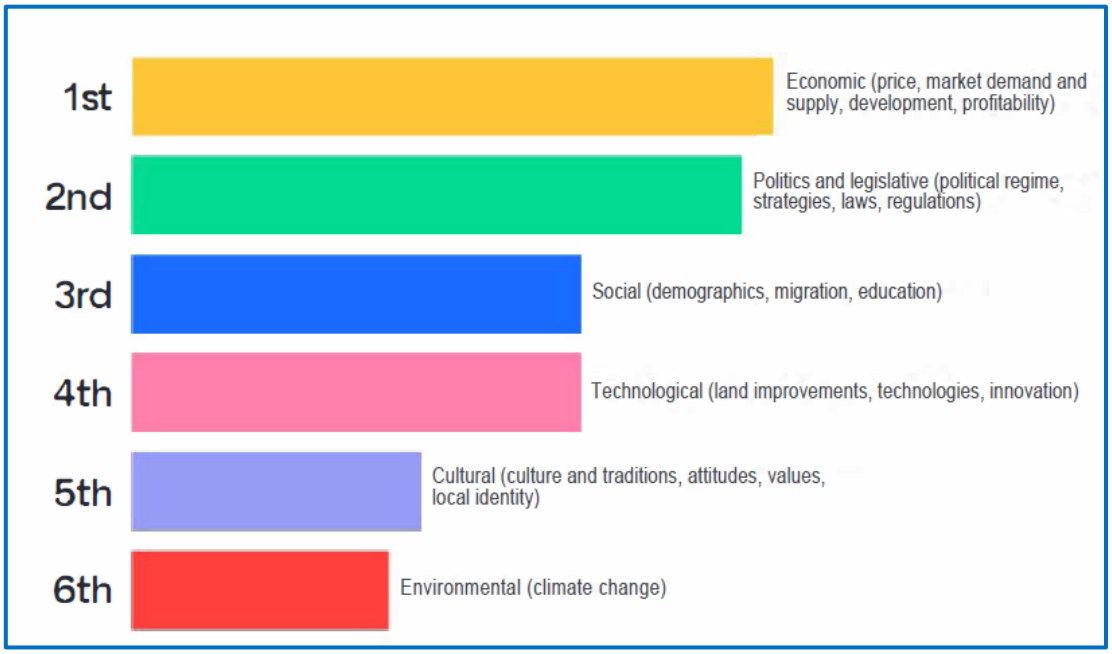
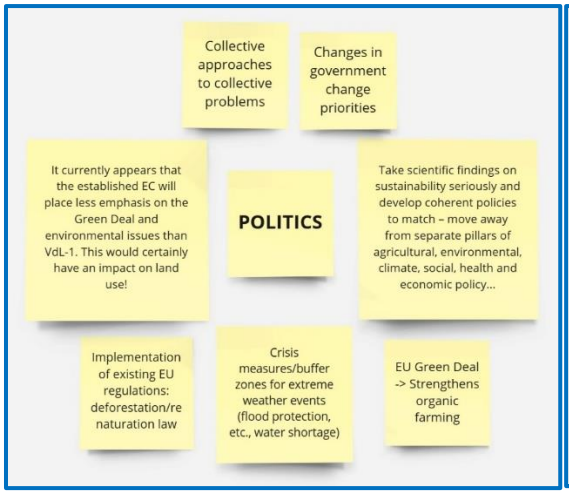


Figure 4: factor ranking results from the 2nd workshop on November 18th


Collective approaches to collective problems
Changes in government change priorities
It currently appears that the established EC will place less emphasis on the Green Deal and environmental issues than VdL-1. This would certainly have an impact on land use!
POLITICS
Take scientific findings on sustainability seriously and develop coherent policies to match – move away from separate pillars of agricultural, environmental, climate, social, health and economic policy...
Implementation of existing EU regulations: deforestation/renaturation law
Crisis measures/buffer zones for extreme weather events (flood protection, etc., water shortage)
EU Green Deal -> Strengthens organic farming


Conflicts of use as already described, despite a focus on competition. Unclear/unattainable targets for companies
Digitalisation leads to simplifications in recording
Farmers
Increased use of precision agriculture by farmers in the near future could lead to significant changes in land use.
EU sustainability reporting, fear of more bureaucracy


EU Nature Restoration Law
Renaturation – conflict and solution
Decision-making based on purely economic or (short-term) political criteria because overarching needs and goals are often difficult to visualise, measure and communicate, and their significance for the individual is often difficult to grasp.
CONFLICTS
Addressing conflicts in the value chain: What are the interests of retailers, processors, farmers, suppliers and consumers?
How can social interests be strengthened here? How can a perspective for sustainable agriculture be created for all actors involved?
Not being guided by profit interests. Important point! The role of trade as a bottleneck for demand (consumers) and supply (producers) and thus a significant influence on land use, but often completely ignored in the debate.
Renewable energies (PV/wind)


Solutions for climate change: (i) different cultures, (ii) greater focus on retention areas and ecosystem services (soil protection, pollination, water retention, etc., etc.)
More training opportunities for career changers in agriculture
Further training on environmental objectives while utilising the knowledge of farmers
Reduction of areas used for animal feed and a broader approach to a national protein strategy (including plant-based proteins for direct consumption); see also the strategies of other EU countries (Belgium...)
Cooperation between and with the chambers (agriculture and economic) and other regional actors
Dialogue between farmers and nature conservationists - renaturation
Conserving land: preserve open spaces for priority uses and expand them where expedient (food production, nature conservation). Concentrate less priority uses on areas that are already sealed. 'Clean up' when an area is no longer in use (example: closed shops and their unused parking spaces). Build upwards (e.g. multi-storey car parks). And much more.
SOLUTIONS
Make ecosystem services provided by agricultural use visible and remunerate them (in whatever form). Example: grazing can keep cultural landscapes open, promote biodiversity, stabilise slopes, make the area more attractive for tourism, etc.
sufficiency
Re-evaluate the export orientation of agriculture (especially animal husbandry)
Reduction in meat consumption + meat production increasingly grassland-based -> increase in grazing
Communication on /offering solutions/possibilities instead of requirements/additional work
Political and economic support for social innovations in production, processing and trade – don't just hope for technical solutions to all problems

CZECHIA

Partner organization: Charles University, Prague, Czechia

Workshop name: Land uses in Greece: Národní seminář „Současné výzvy v oblasti využívání půdy, hospodaření s půdou a budoucí perspektivy" (in Czech)
National Workshop "Current challenges in land use, land management and future perspectives" (in English)
Date: 18 October 2024, 11:00-13:00
Format: online
No of participants: 12, 6 external
Participant institutions/organizations: Charles University, Prague, International Federation of Agricultural Journalists, Czech University of Life Sciences, Prague, Research Institute for Soil and Water Conservation, Association of Private Farming of the Czech Republic

Country profile

At the beginning of the workshop, three introductory presentations were delivered:

Towards Sustainable Land-use Strategies in the Context of Climate Change and Biodiversity Challenges in Europe: Introduction of the project Horizont Europe – Lucie Kupková (Charles University, Prague). The presentation introduced the Euro-Land research project and its main research objectives: 12 EU Member States, 15 partners; the aim is to identify, develop, test and implement integrated tools to better understand the factors behind land use decisions; to increase awareness and stakeholder engagement on climate change and biodiversity challenges; 7 work areas; assessing land use behaviour across Europe; Land use in the context of climate change, biodiversity challenges; mapping land use and land cover patterns; to create an interactive toolkit that allows users to experiment with different land use patterns; develop holistic and systems thinking; to promote sustainable land use and decision-making at all levels; research at different ordinal levels (Europe, countries, model territories); model area in Czechia: the Krkonoše Mountains.

Introduction of panellists – Vít Jančák (Charles University, Prague – specialist on agriculture): Individual panelists and their professional and research focus were introduced in the presentation: Ivan Bičík (Charles University, Prague – research on land use land cover change), Petr Havel (agrarian analyst, International Federation of Agricultural Journalists), Jiří Hrabák (agrarian economy analyst, Czech University of Life Sciences, Prague), Zbyněk Janoušek (Research Institute for Soil and Water Conservation), Zdeněk Kučera (Charles University, Prague, landscape ecologist), Radim Perlín (Charles University, Prague, focused on rural research), Tomáš Zavadil (Association of Private Farming of the Czech Republic).

Land use dynamics in Czechia: research methodology, main results and development trends – Vít Jančák (Charles University, Prague): The presentation presented the main theses of the research on land use dynamics, which has a long tradition at the Faculty of Science of Charles University (team under the leadership of prof. Bičík). The research methodology based on the data on the structure of the land stock from 1845, 1896, 1948, 1990, 2010, 2020 was presented in detail. The data (LUCC UK Prague database) allows to analyze the state of land use at the beginning of market farming (1845) and at its end (1948), then allows to analyze the state and development during the period of central planning (1948-1990) and then ten or twenty years of transformation to new market conditions (2010 and 2020). A typology of the drivers of socio-spatial change (political, economic and technological, demographic, cultural and social) was also presented.

Furthermore, major processes of landscape change at different stages of development were presented.
1845–1896: the increase in the area of arable land completely dominates the territory of Czechia, the increase in forest areas, especially in the higher altitudes, starts to be applied; in this period, changes in categories occurred in about 20% of the territory.
1896–1948: the changes are more varied than in the previous period, the most important processes being those associated with urbanisation, with an increase in forest areas, particularly at the expense of arable land (but also other categories of agricultural land), being a significant process throughout the southern half of the Czechia.
1948–1990: urbanization dominates, exceptional development of buildings (dominates in about a quarter of the ZÚJ); afforestation concentrated on small areas, mainly in border areas and in parts of western Bohemia (post-war emigration of Czech Germans); agricultural intensification exceptional (increase in arable land in the most fertile areas of Czechia).
1990–2020: processes that shaped the post-socialist development of the landscape; grassing (border mountain areas, inner periphery) – a consequence of the decline in agricultural intensity; urbanisation (increase in built-up and other areas) – the hinterland of large cities, development axes, construction of trans-regional roads connecting Prague and the main centres of population of Czechia and Central Europe, in Moravia the connection of the two main centres of population.

Factors ranking

Factors influencing land use change are mainly factory political and legislative factors (political regime, strategies, laws, regulations), economic factors (prices, market demand and supply, development, profitability), social factors (demography, migration and education), environmental factors (climate change), technological factors (land development, technological innovation), cultural factors (culture and tradition, attitudes, values, local identity).

DENMARK

Partner organization: University of Copenhagen, Department of Geosciences and Natural Resource Management

Workshop name: Conference: Denmark's land areas – transformation for the future (Konference: Danmarks arealer – transformation til fremtiden)
Date: 9th October 2024, Aarhus City Hall, Denmark
Format: in person
No of participants: over 200 (9 participants recruited to answer mirror workshop questions)
Participant institutions/organizations: Governmental institutions (agricultural ministry, environmental ministry), regions, municipalities including both professional planners and politicians on all levels. NGOs (all major Danish NGOs), academia (all universities), agricultural advisors, businesses, consultants, water utility companies, water councils, energy companies and architects. The 9 recruited participants from the workshop represented the following organisations/sectors: Municipal planner (3) representing different sectors (climate, countryside planning, urban planning), Nature Agency State level (2), Energy sector (2), Consultant (1), anonym (1).

Country profile

Denmark is dominated by intensive agricultural land use, very little nature areas and facing serious issues with compliance to the EC water directive (pollution of water bodies and coastal waters), the habitat directive, the EU biodiversity aims, and preservation of clean ground water resources. In addition, Denmark is facing challenges with climate change impacts related to floods and erosion, clean ground water (drinking water) and preservation of biodiversity.
The background for the conference and the debate was a very ambitious so-called “tree-part agreement” between the Danish national government and the agricultural sector and the Danish Nature Conservation Society aiming for a large-scale conversion of farmland into forest and wetlands and a carbon tax on agriculture and a reduction of agro-fertilizers. The aim is a total conversion of 10% of the territory of Denmark before 2045.

Land use in Denmark: Agriculture: 60%, Forest 13%, Nature 11%, Urban and infrastructure 14%, other 2%.

Land sustainability challenges

Factors ranking

Rank	Options	Average rank
1	Economic (price, market demand and supply, development, profit)	1.42
2	Political and regulatory (political regime, strategies, laws, regulations)	1.75
3	Environmental and climate (climate change)	2.85
4	Cultural (culture and traditions, attitudes, values, local identity)	4.33
5	Social (demography, migration, education)	4.4
6	Technological (land improvements, technologies, innovation)	5

Support of the current policies to sustainable land management

To a very small extent	1
To a small extent	6
I don’t know/I am not familiar with these policies	1
To a large extent	0
To a very large extent	0

Germany

Partner organization: 01/HAW Hamburg University of Applied Sciences and 13/IAMO

Workshop name: Landnutzung und Landmanagement in Deutschland – aktuelle Herausforderungen und Zukunftsperspektiven
in English: Land use and land management in Germany - current challenges and future prospects
Date: 1 Oct 2024, 10:00-12:15 (CET)
Format: online
No of participants: 7 (of 14 previously registered ones)
Participant institutions/organizations: Academia, business association, federal authority, federal state representative, NGO

Country profile

In Germany, a decline of agriculturally used land has been observed since the 1950s whereas forest cover seems to have been stable. Land has been increasingly converted to meet housing and infrastructure needs. Less crops are grown, and farming focus has been laid on growing cash crops. German farms increased in size and assets available which resulted in higher productivity and increasing specialization levels, reflecting the overall trend towards agricultural intensification. Among the observable results of this agricultural intensification are: Less diverse agriculture, higher use of pesticides, higher nutrient loads, reduction of organic substance in soils and ground compaction. This leads to loss of biodiversity and reduced CO2 storage in soils.

In Germany, agriculture is under pressure from various sides, with the contrasting objectives being observable. In the centre of attention of of land use and land management challenges in Germany, are aspects of agricultural production and food security, decent income and low prices of agricultural produce (supply), climate protection and adaptation, conservation and environmental protection, drinking water protection and water storage/conservation, effects of intensification and loss of biodiversity, greenhouse gas emissions and reduced CO2 capture potential. To improve biodiversity, it is needed to lessen intensification and use of pesticides, increase on field diversity and caried crop rotation, introduction of nature-based solutions and more organic farming, combined with increased conservation and extensive land use.

Concerning future scenarios and impacts of climate change affecting Germany, studies (e.g. Cerspiu et al., 2023) observed changing climatic conditions in German cities (ref period 1986-2015), suggesting a shift in climate conditions similar to those in southern France by the middle of the century (2031-2060). For agriculture, these changes may lead to more extreme rainfall extreme, heavy rainfall, more drought, more flooding, increase of overwintering pests, more overwintering pests, stronger weed growth and less cooling effects due to more efficient water use. However, agriculture may benefit as well from a changing climate by extended growing seasons, higher temperatures, warmer soil temperature during spring, higher CO2 content due to higher level of photosynthesis and water utilization, lower risk of late frost in spring or early frost in fall, and an increasing freeze-thaw cycles leading to increased soil moisture in wintertime.

Concerning agricultural yields, it has been found that yields fluctuate, but climate change is but one factor influencing this development: Irradiation often had the greatest influence on yield losses, drought appears to be an important influencing factor for maize growing, and non-climatic factors often cause yield losses. To avoid future yield losses, adaptations are considered crucial.

In conclusion, it can be stated that science can inform on suitable approaches for improved climate change and biodiversity protection, more sustainable land use and new approaches for sustainable water management but an overall paradigm shift seems necessary, e.g. by developing a sustainable vision for agriculture, by tying subsidies to agriculture to public services, by more sustainable consumption patterns, and by seizing the opportunities of digitalization.

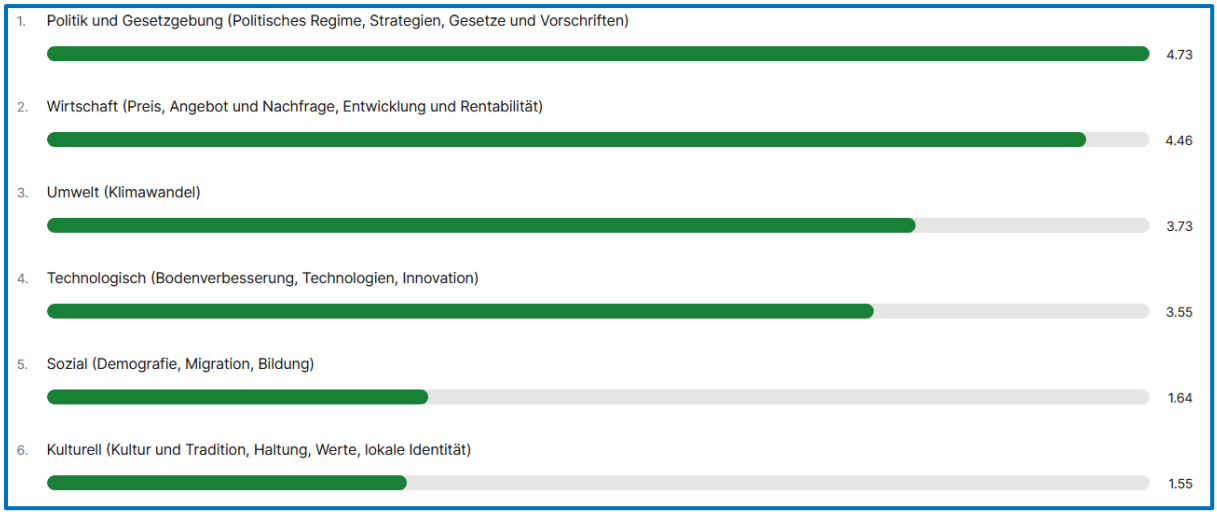
Land sustainability challenges

Translation of answer categories:

Konsumverhalten –
GAP für öffentliche Güter – common agricultural policy for public goods
Effektive Klimapolitik – effective climate policy
Vergütung von Produkten – payment for products
Gesellschaftliche Akzeptanz – societal acceptance
Offenheit für neue Sorten – openness for new varieties
Wassermanagement, übergreifend – water management, overarching perspectice
Anpass. Fördermaßnahmen – adaptative measures
Produktpreise – price of products

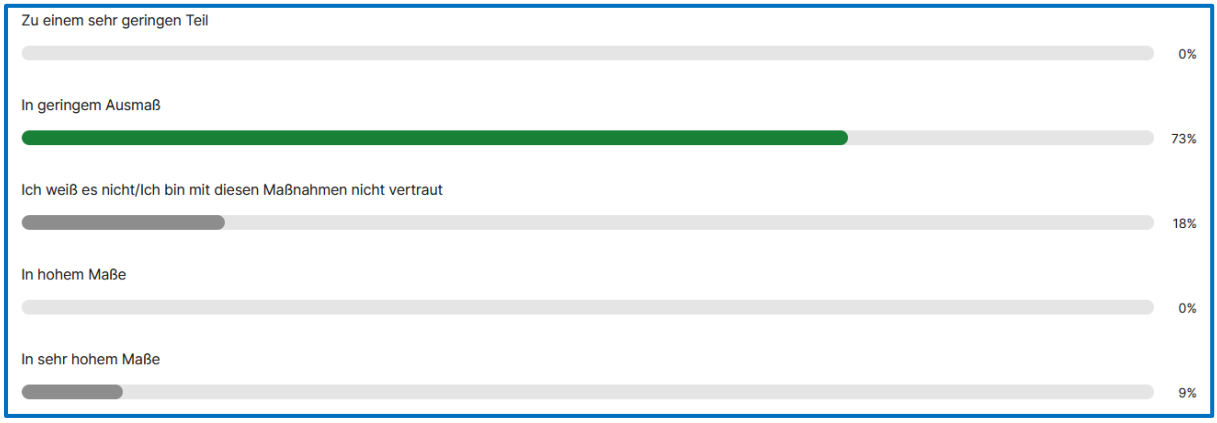
Factors ranking

Ranking translation:
1 – Policy and regulatory environment
2 – The Economy
3 – The Environment
4 – Technologies
5 – social aspects
6 – cultural aspects

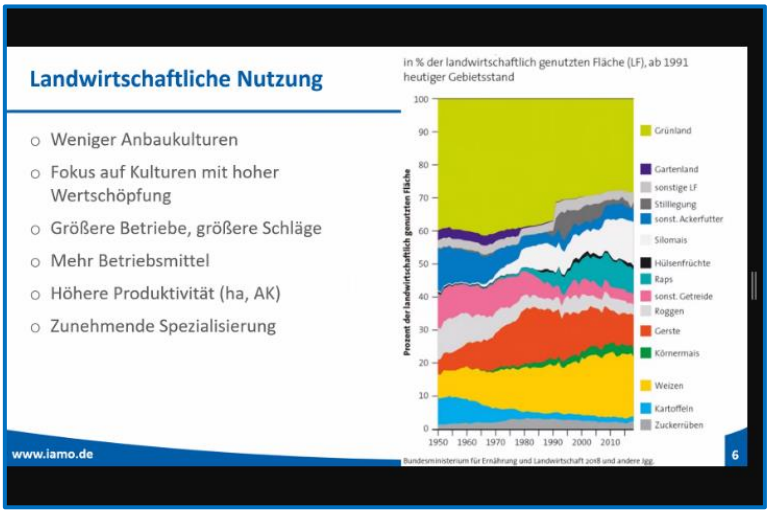


Support of the current policies to sustainable land management

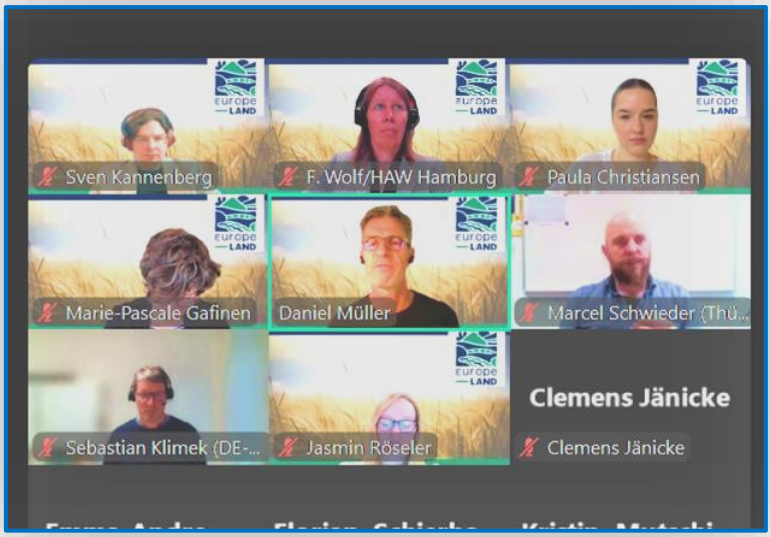
See below a Screenshot of the Slido tool used to determine Factors' Relevance (11 responses).



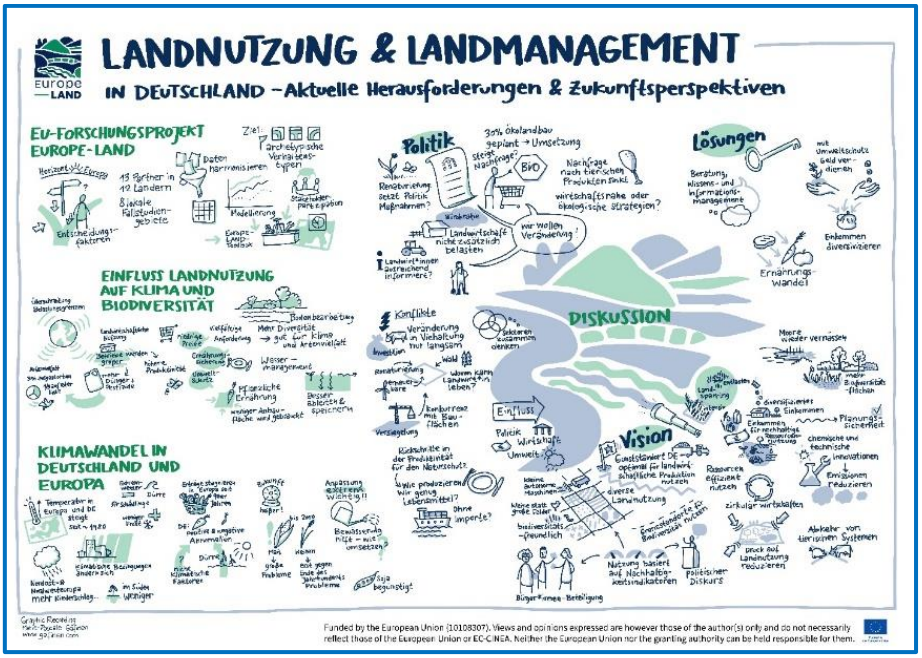
Ranking translation: 73% to a small extent, 18% don't know, 9% to high extent



Screenshot selected online delegates who gave consent to be shown



Visualisation of key aspects of stakeholder discussion during the online event



Greece

Partner organization: Aristotle University of Thessaloniki

Workshop name: Land uses in Greece: current challenges and future perspectives
Date: October 23rd, 2024
Format: online
No of participants: 19 (external), 28 (total)
Participant institutions/organizations: National authorities (central government, regional offices), NGO, Research Organisations

Country profile

Greece's land use and management challenges are deeply influenced by its historical shift from an agrarian society to an urban-industrial economy. In the 19th century, following independence, extensive agricultural reforms and land redistribution efforts encouraged rural populations to cultivate productive lowland areas. This period marked a significant increase in agricultural land use, laying the foundation for Greece's economy. However, after World War II, Greece experienced rapid urbanization and industrial growth, with many rural residents migrating to cities, especially Athens and Thessaloniki. This urban expansion not only reduced available farmland but also heightened environmental pressures, leading to land fragmentation, deforestation, and growing demands on limited natural resources.

Modern Greece faces pressing land use challenges that are now compounded by climate change. Urban sprawl, tourism-driven development, and intensive agricultural practices continue to strain the environment, particularly as cities expand further into natural landscapes, altering local ecosystems and microclimates. Key environmental concerns include deforestation, which diminishes natural CO_2 absorption, and unsustainable agricultural practices that contribute to soil degradation and greenhouse gas emissions. Additionally, Greece's coastal and low-lying areas are particularly vulnerable to rising sea levels, which pose significant risks to agriculture, urban infrastructure, and tourism by increasing the likelihood of flooding and saltwater intrusion.

Looking ahead, Greece must adapt to projected climate changes, which include a potential temperature increase of up to 3°C by 2050, resulting in more severe heatwaves, droughts, and wildfires. To enhance climate resilience, Greece is prioritizing strategies such as developing drought-resistant crops, strengthening water management systems, and advancing sustainable urban and coastal planning. National and regional policies now emphasize reforestation, eco-tourism, and climate-resilient agriculture, supported by advanced technologies like GIS for environmental monitoring and resource management. Building water storage infrastructure, reinforcing flood protection, and implementing adaptive land use policies are essential steps toward maintaining a balance between Greece's historical agricultural roots and the demands of a climate-resilient future.

Land sustainability challenges

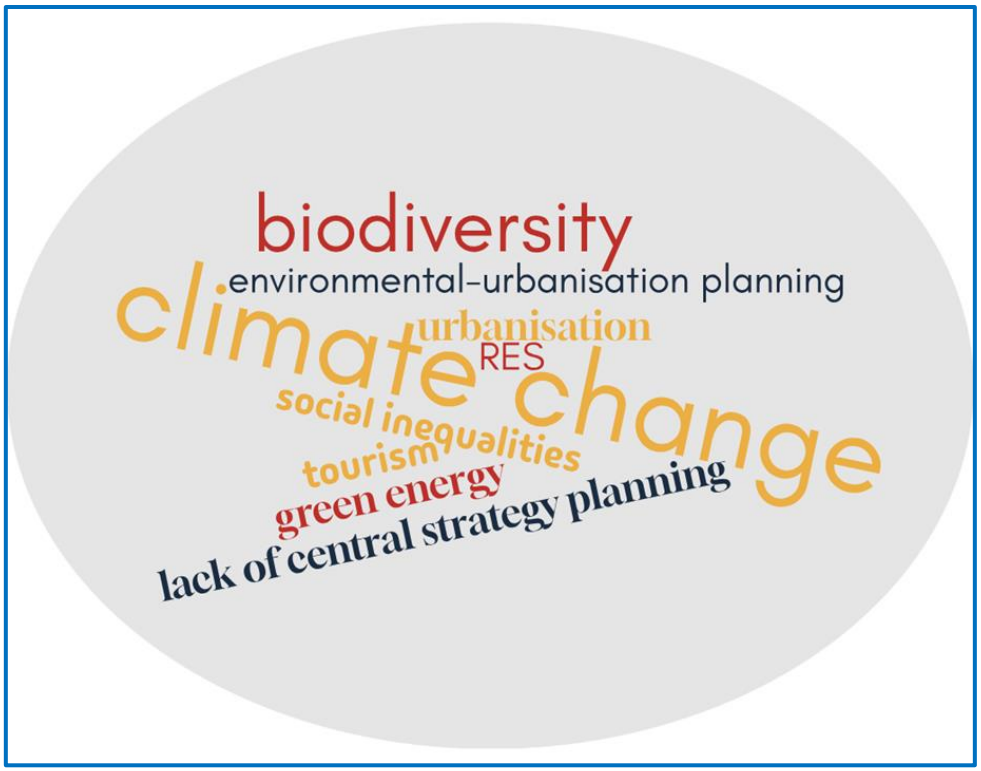


Figure 5: The keywords provided by the participants of the LL

Factors ranking

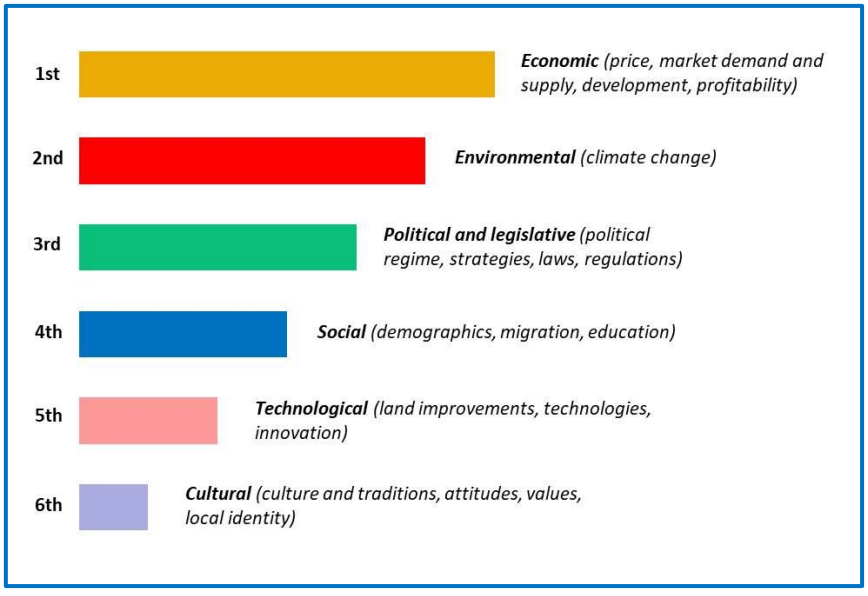


Figure 6: In the question regarding the main factors contributing to changes in land use in Greece, participants ranked (almost unanimously) the Financial Factors in the first placed followed by Environmental factors, Political factors, Social, Technoogical and last, but not least, cultural factors. This result led to a very fruitful conversation during the LL.

Support of the current policies to sustainable land management

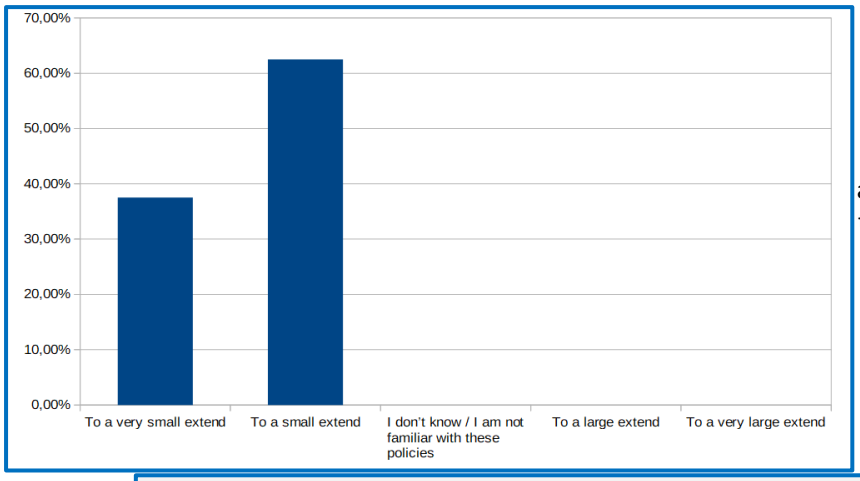


Figure 7(a) and (b): Participants voted, that existing policies on agriculture, the environment, and climate change contribute to a very small extent and to a small extent to sustainable land use in Greece. This was also expressed during the discussion that followed.

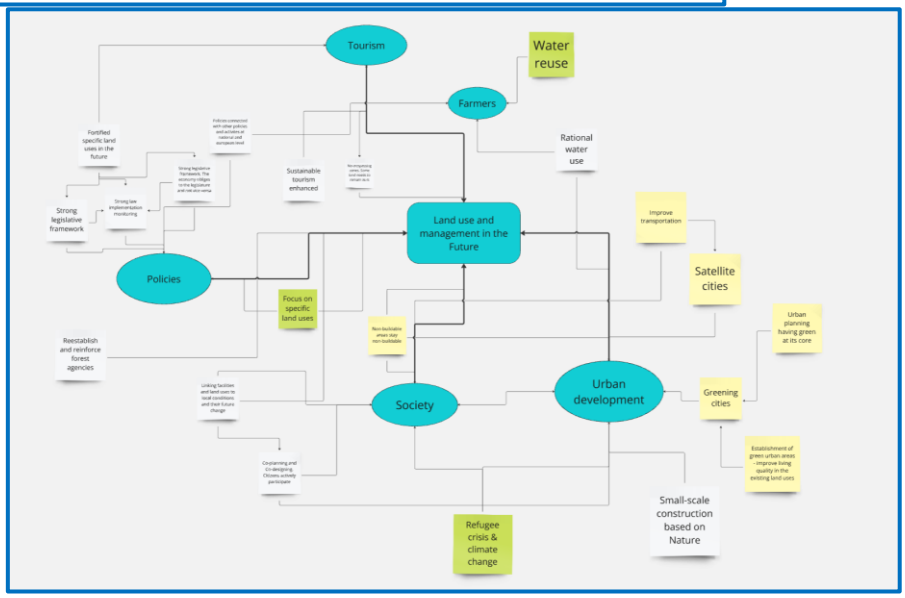


Figure 8: Conceptual map of the discussions during the Mirror Workshop in Greece

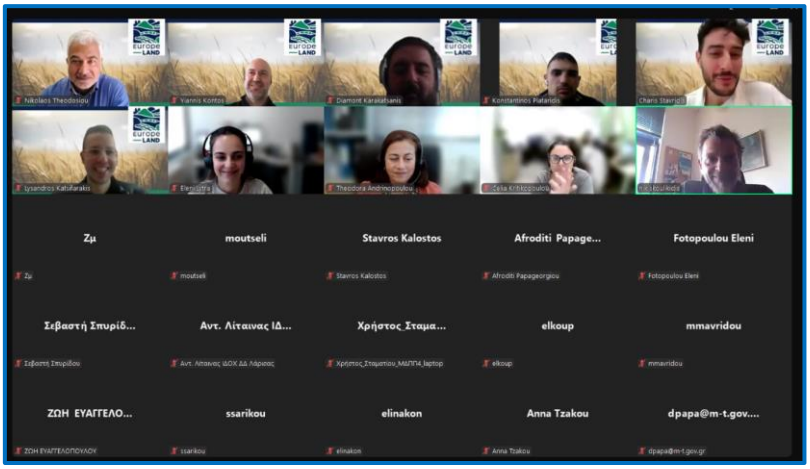


Figure 9: Screenshot with some of the participants of the Mirror Workshop

ESTONIA

Partner organization: Estonian University of Life Sciences

Workshop name: Sustainable land use in the context of climate change and biodiversity loss
Date: nNovember 27th, 2024
Format: in person
No of participants: 32
Participant institutions/organizations: representatives of local government; Ministry of Regional Affairs and Agriculture; Environmental Board of Estonia; Environment Agency; Estonian Society for Nature Conservation; local farmers, foresters and other entrepreneurs; academic employees and teachers

Country profile

Estonia is one of the European countries with a significant proportion of forested and agricultural land, offering a unique blend of natural and cultivated landscapes. Forests cover over 50% of the country's territory, while agricultural lands account for around 23%, distributed across a mix of plains, wetlands, and coastal areas. The diverse topography and climate conditions influence Estonia's land use patterns, balancing agricultural productivity with conservation priorities. Estonia's agricultural landscape is marked by a mosaic of small-scale fields interspersed with forests and wetlands, reflecting the legacy of smallholder farming traditions (Jürgenson, 2016).

Estonia has experienced profound changes in land use during the post-Soviet period, with the dissolution of collective farms (kolkhozes and sovkhozes) and the transition to a market economy. The privatization of agricultural lands in the 1990s resulted in fragmented land ownership, with over 60% of farmland being divided into small-scale plots of less than 10 ha (Palang et al., 2006). Many smallholders lacked the technical expertise or financial resources for efficient farm management, leading to the abandonment of less productive lands, especially in upland and wetland areas (Mander et al., 2004). However, since the beginning of the 2000s, agriculture in Estonia has continuously intensified again, the average farm size has increased about 10 times, and land has been concentrated in the hands of a smaller and smaller number of owners. The same applies to forestry, which has resulted in nearly twenty years of overharvesting and subsequent environmental problems. Currently, the average (arithmetic) farm size in Estonia is approximately 100 hectares, but the median size is probably much larger. Intensification has a positive effect on productivity but it has several negative effects for food security, land use and socioeconomic aspects.

After joining the European Union in 2004, Estonia's agricultural policies began aligning with the Common Agricultural Policy (CAP), which provided access to EU subsidies for rural development and agricultural modernization. Among boosting the intensification of agriculture have the subsidies supported also development of organic farming, which expanded to encompass ~22% of total agricultural land by 2022, making Estonia one of the leading European countries in terms of organic farming share (Arold et al., 2020).

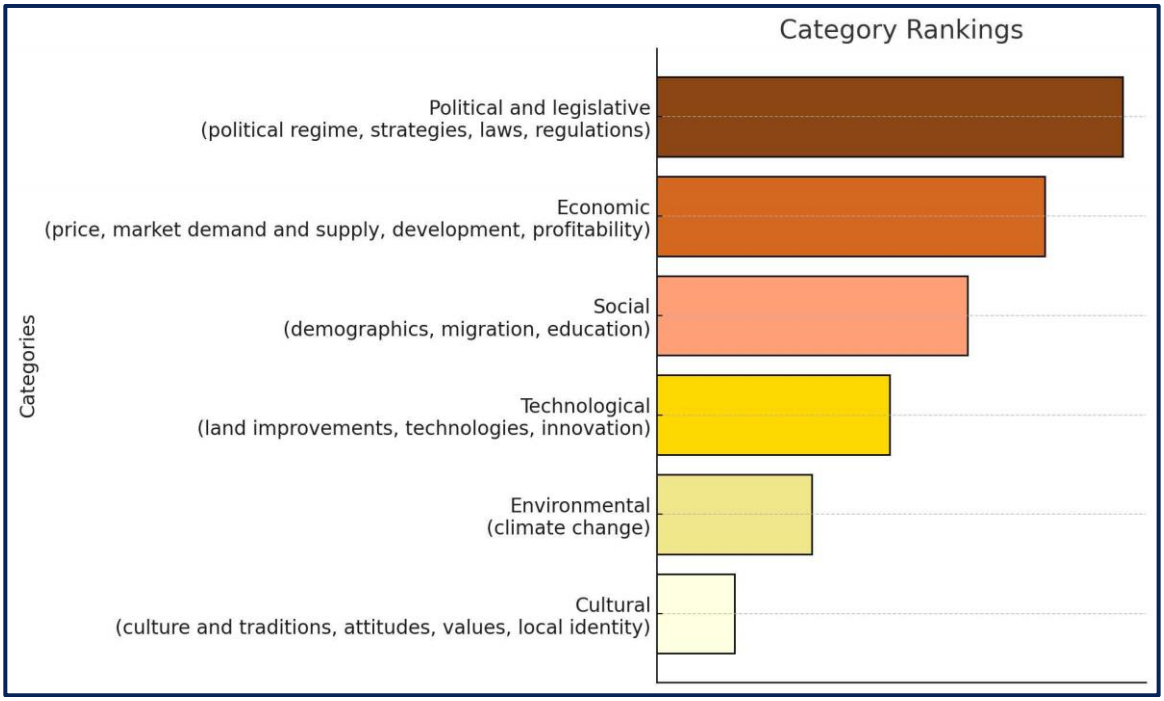
Estonia's agriculture faces critical challenges from climate variability and change. Rising temperatures, shifting precipitation patterns, and increased frequency of extreme weather events such as droughts, storms, and flooding pose significant threats to productivity. Coastal lowlands are particularly vulnerable to sea-level rise and salinization, impacting agricultural viability (Sepp et al., 2018).

References:

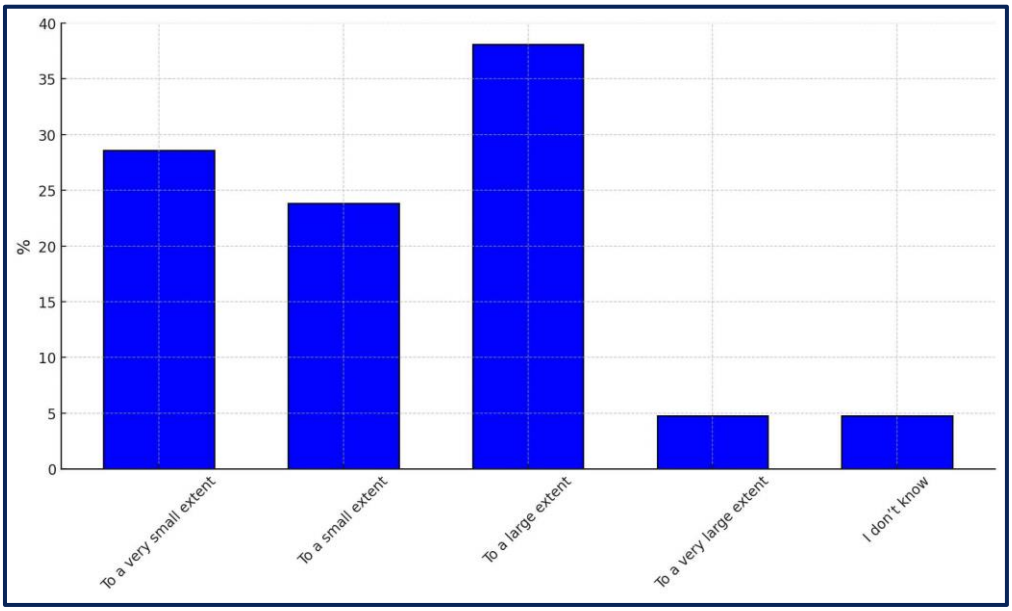
1. Mander, Ü., et al. (2004). "Landscape changes and their driving forces in rural areas in Estonia."
2. Palang, H., et al. (2006). "Land use and landscape change in Estonia: The role of agricultural abandonment."
3. Arold, I., et al. (2020). "Organic farming in Estonia: Trends and achievements."
4. Sepp, M., et al. (2018). "Climate change and its implications for Estonian agriculture."

Land sustainability challenges

Factors ranking



Support of the current policies to sustainable land management



Pictures from the event

Italy

Workshop Objectives

The main objectives were:

Partner organization: University of Bologna

Workshop name: Sfide Attuali e Prospettive Future dell'Uso e della Gestione del Suolo in Italia (in Italian)
Present and future land use and land management challenges in Italy (in English)
Date: 30 October 2024 h: 10:00-13:00
Format: On-line - Teams Webinar
No of participants: 32 – of which 22 external (from 44 total registrations)

- To address Italy's current land use and management challenges, including erosion, urbanization, and carbon emissions.
- To explore the role of data integration in enhancing agricultural monitoring and supporting effective policymaking.
- To discuss the future of agricultural policies and the potential benefits of carbon credit systems for sustainable practices.
- To engage young farmers in sustainable land use through policy incentives and by reducing barriers to land access.

Workshop Outcomes

Data Integration and Monitoring

High-resolution satellite data (e.g., AGEA's 20 cm resolution imagery) and automated machine learning systems were highlighted as crucial for precise agricultural monitoring. AGEA presented its Carta Nazionale dei Suoli (National Soil Map) as an advanced tool to establish baseline data across multiple thematic layers, facilitating improved policy-making and monitoring processes for agricultural activities. This tool enables standardized land parcel analysis across Italy, aiding in accurate policy assessments.

Key points:

- Improved accuracy in monitoring allows for robust policymaking and supports grant compliance.
- Satellite-based precision monitoring is expected to replace traditional manual data collection, minimizing errors and biases.
- A coordinated effort among regional bodies ensures consistency in data application, with a multi-tiered quality control system to ensure data reliability.

Environmental Sustainability and Carbon Farming

The workshop included significant discourse on carbon credits and sustainable land practices:

- Participants emphasized that a standardized system for carbon credit calculation could incentivize sustainable practices without imposing excessive administrative burdens.
- There was widespread agreement on using satellite-based data systems for large-scale, automated carbon assessment, thus streamlining monitoring and compliance.

- Coldiretti and other agricultural organizations stressed that the agricultural sector could benefit significantly from carbon credits, particularly if bureaucratic processes are minimized.

Youth Engagement and Agricultural Policy

Youth engagement emerged as a pressing issue. Representatives from Confagricoltura, Coldiretti, and AGIA-CIA highlighted that:

- The average age of Italian farmers remains high due to difficulties young farmers face in accessing land and financing.
- Current incentives under Italy's PAC (Common Agricultural Policy) provide some support, but a longer-term commitment is needed to attract and sustain young agricultural talent.
- A flexible framework that extends benefits beyond the current five-year limit for young farmers was proposed to support long-term agricultural careers better.

Renewable Energy and Land Use

The workshop addressed the contentious issue of solar panel installation on agricultural lands. Coldiretti emphasized a balanced approach, advocating for:

- The restriction of solar installations to non-arable or contaminated lands to preserve agricultural productivity.
- Favoring “Agri-voltaic” systems that allow for both energy production and crop cultivation, supporting a dual-purpose land use.

Latvia

Partner organization: University of Latvia (UL)

Workshop name: Land use and management challenges: Future vision in Latvia
Date: October 16, 2024, 14:00-17:00
Format: in person and online
No of participants: 29 participants (including 21 persons attending on site and 8 persons online)
Participant institutions/organizations: Governmental institutions; non-governmental organizations; businesses and private land owners (related to agriculture, forests, and minerals mining); farmers; research and educational institutions

Country profile

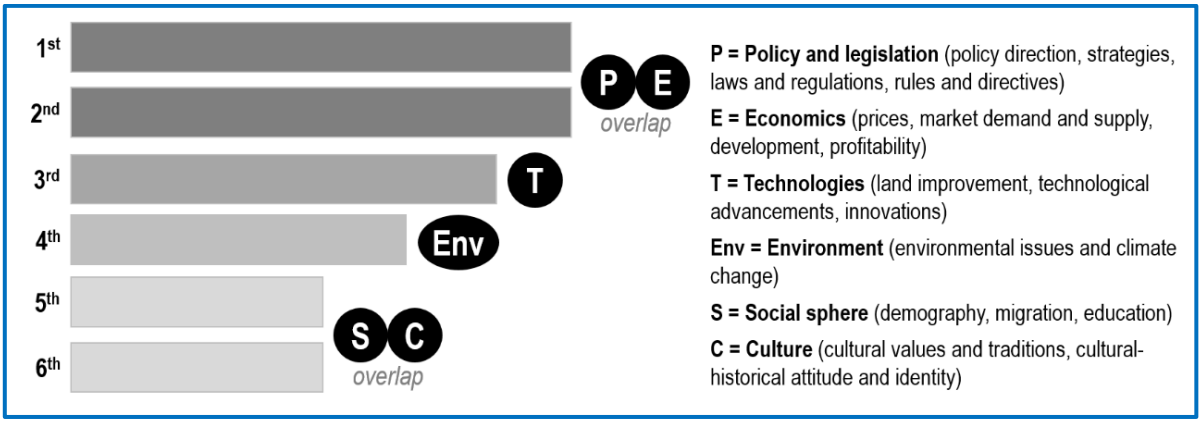
Currently, land use in Latvia is principally characterized by forests, which cover around 52% of the country's area, followed by agricultural lands, which make up roughly 30%. Land use change in Latvia has been essentially affected by historical, economic, and political factors, coupled with the EU (European Union) membership policies and market demands. Historically, the periods of occupation have negatively affected land use and management implementation, shifting the focus from sustainability to rapid resource extraction and industrial exploitation. Such practices can lead to long-term ecological consequences, including loss of biodiversity, soil degradation, and altered hydrological cycles, which could take decades or even centuries to remediate. The post-Soviet period led to land denationalization, significantly changing land use patterns.

However, sustainable land use practices have been adopted to balance business interests and environmental conservation which is disputable issue at all times between particular interests. Although Latvia is not highly urbanized compared to other European countries, there is a noticeable trend towards urban concentration, particularly in the capital, Riga. Riga alone accounts for about one-third of the country's total population, and this trend exerts pressure on land use in the surrounding areas. Latvia has been experiencing a trend of increasing urbanization, partly promoted by internal migration from rural to urban areas for economic opportunities. This internal migration has led to a decline in the population of rural areas and has added to the challenges of land use management in the country, particularly concerning the provision of services and infrastructure.

At the same time, membership in the EU has led to increased investment in infrastructure and agricultural practices, affecting land use. Latvia is also facing climate-related challenges that are expected to influence land use change, including shifts in agricultural zones and forest compositions. To manage this issue, Latvia is engaged in sustainable land management practices, including participating in international initiatives like REDD+ and locally driven policies to preserve biodiversity and promote sustainable agriculture.

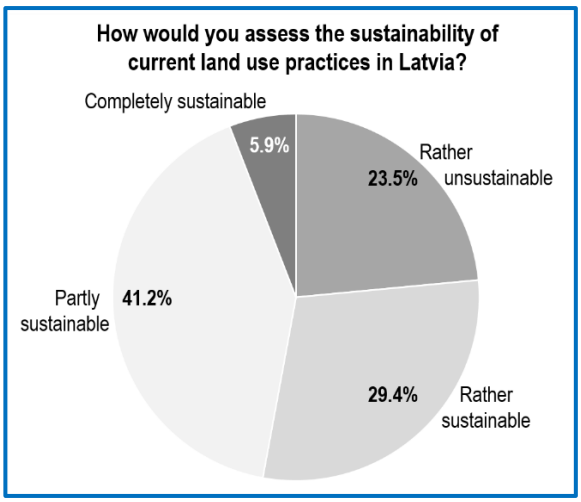
Land sustainability challenges

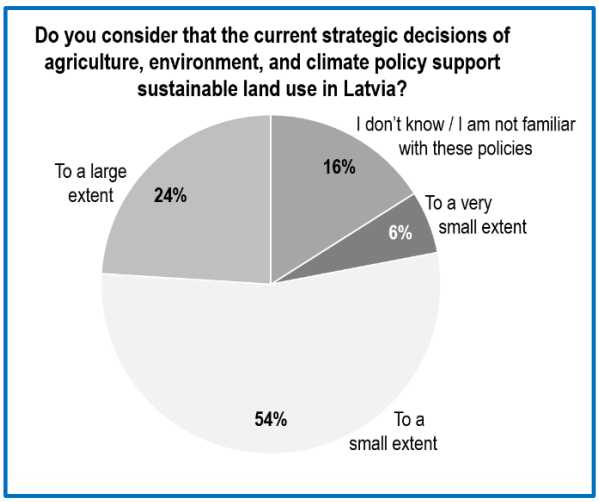
Factors ranking

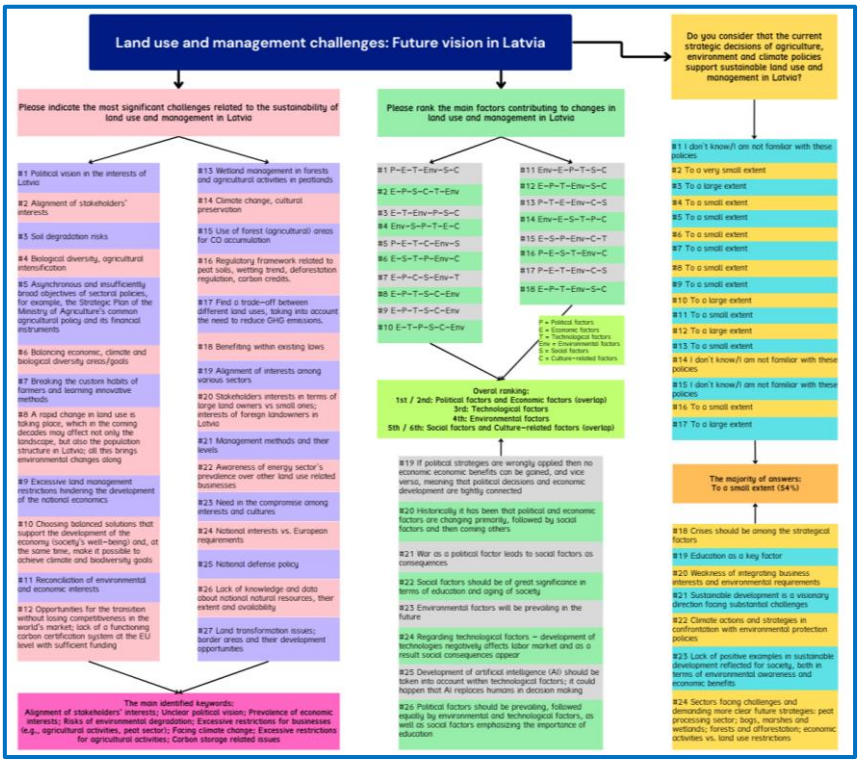


Support of the current policies to sustainable land management

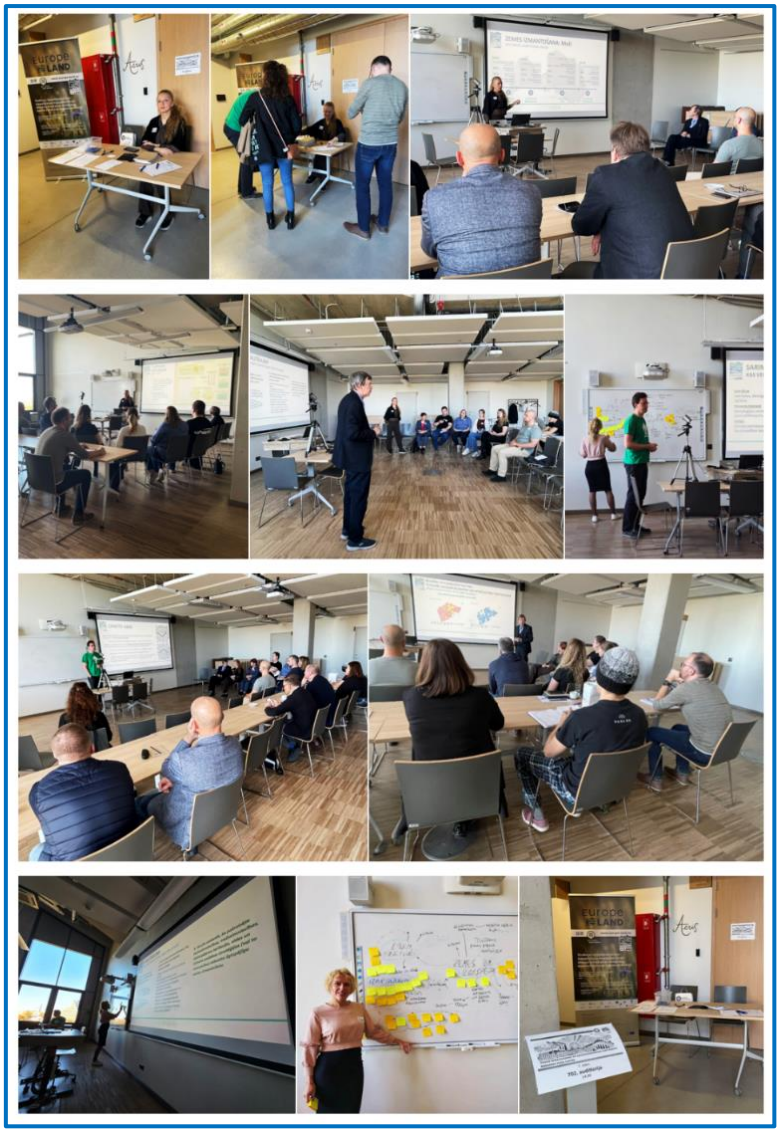
Regarding the support to current policies, the majority of answers (54%): to a small extent.







Conceptual answers-based map



Workshop in pictures

Poland

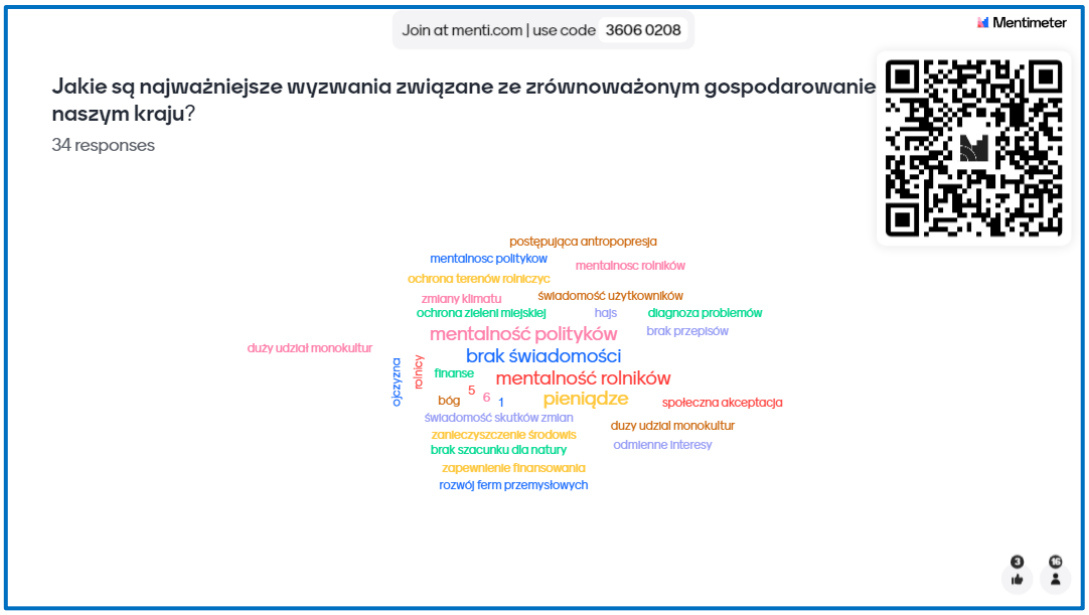
Partner organization: Bialystok University of Technology

Workshop name: Warsztat Narodowy zrównoważone zarządzanie użytkowaniem gruntów – obecne i przyszłe wyzwania,
English: National Workshop Present land use and land management challenges and future perspectives
Date: 17 October 2024, 9:00-11:00
Format: On-line Teams Platform
No of participants: 27, 21 external
Participant institutions/organizations: ministeries, Regional governmental institutions; Research institutions; HEIs

At the beginning of the workshop, three introductory presentations were delivered:

- Challenges for Poland in the context of Regulation (EU) 2024/1991 of the European Parliament and Council of 24 June 2024 on the restoration of natural resources – Piotr Kropiński (Department of Nature Conservation, Ministry of Climate and Environment)
- EU Biodiversity Strategy for 2030** – Anna Krysztopik (Department of Environmental Protection, Marshal's Office of the Podlaskie Voivodeship)
- Directions of actions and the current results in managing the Agricultural Property Stock of the State Treasury** – Bogdan Podgórski (Department of Resource Management, National Agricultural Support Center)

Land sustainability challenges



Money/finances – 5 answers, Farmers' mindset – 4 answers, Politicians' mindset – 3 answers, Lack of awareness – 2 answers, High share of monocultures – 2 answers, Lack of regulations – 1 answer, Lack of respect for nature – 1 answer, Problem diagnosis – 1 answer, Protection of agricultural land – 1 answer, Protection of urban green areas – 1 answer, Diverging interests – 1 answer, Homeland – 1 answer, Increasing anthropopressure – 1 answer, Development of industrial farms, Social acceptance – Environmental pollution – 1 answer, Climate change, Awareness of the effects of changes – 1 answer, User awareness – 1 answer.

Factors ranking

The ranking of factors influencing changes in land use is presented below (Figure 1). According to experts, **economic factors** (prices, market demand and supply, development, profitability) **have the strongest impact on these changes**. **Social factors** (demographics, migration, and education) **were ranked second** by respondents. **Political and legislative factors** (political regime, strategies, laws, regulations) **took third place in the ranking**. In the opinion of experts, environmental factors (climate change), cultural factors (culture and traditions, attitudes, values, local identity), and technological factors (land improvement, technological innovations) have a lesser influence on changes in land use. These groups of factors ranked fourth, fifth, and sixth, respectively.

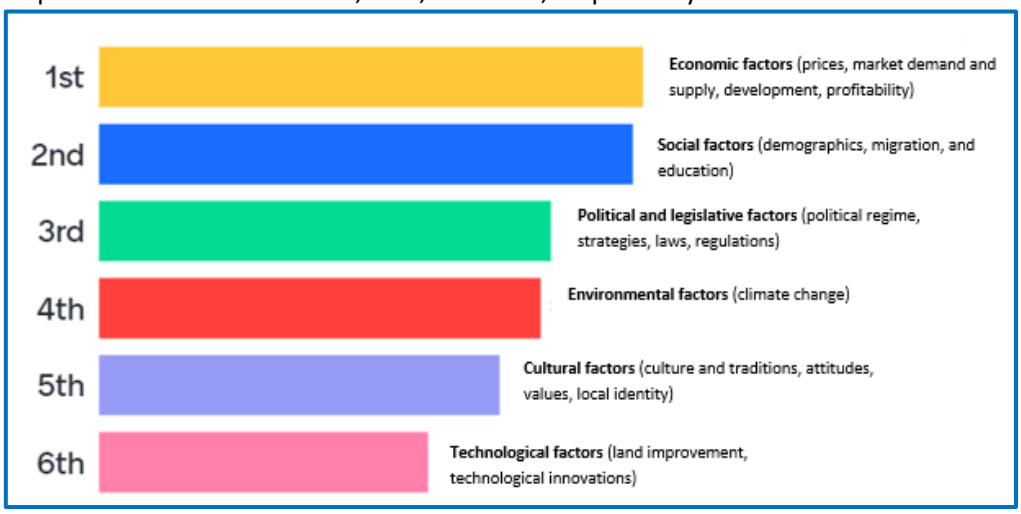


Figure 1: The ranking of factors influencing changes in land use
Source: own study in the basis of Mentimeter results.

Support of the current policies to sustainable land management

In the opinion of most experts, support from current policies for sustainable land management is insufficient (Figure 2).

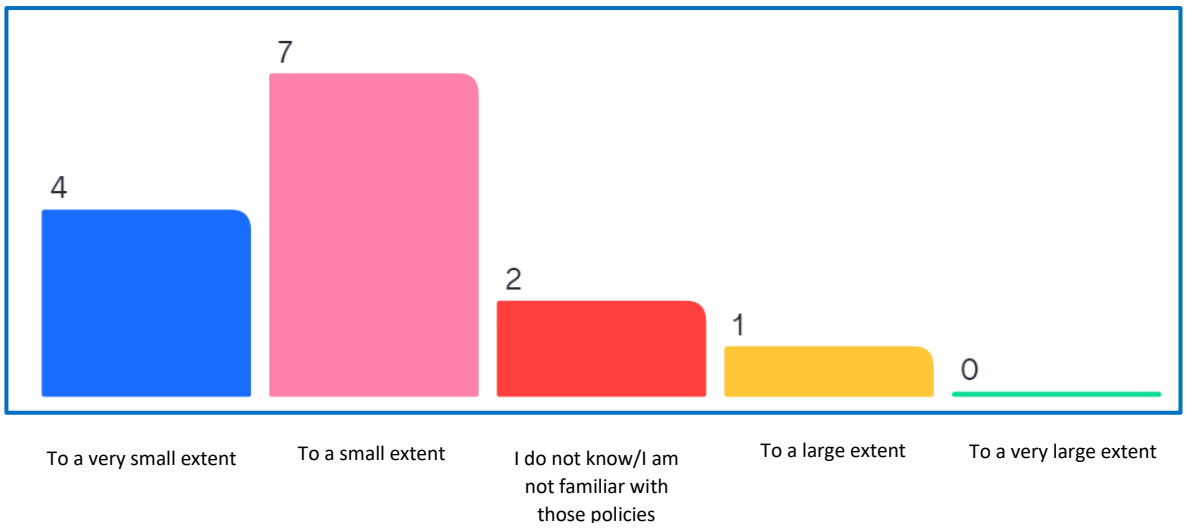
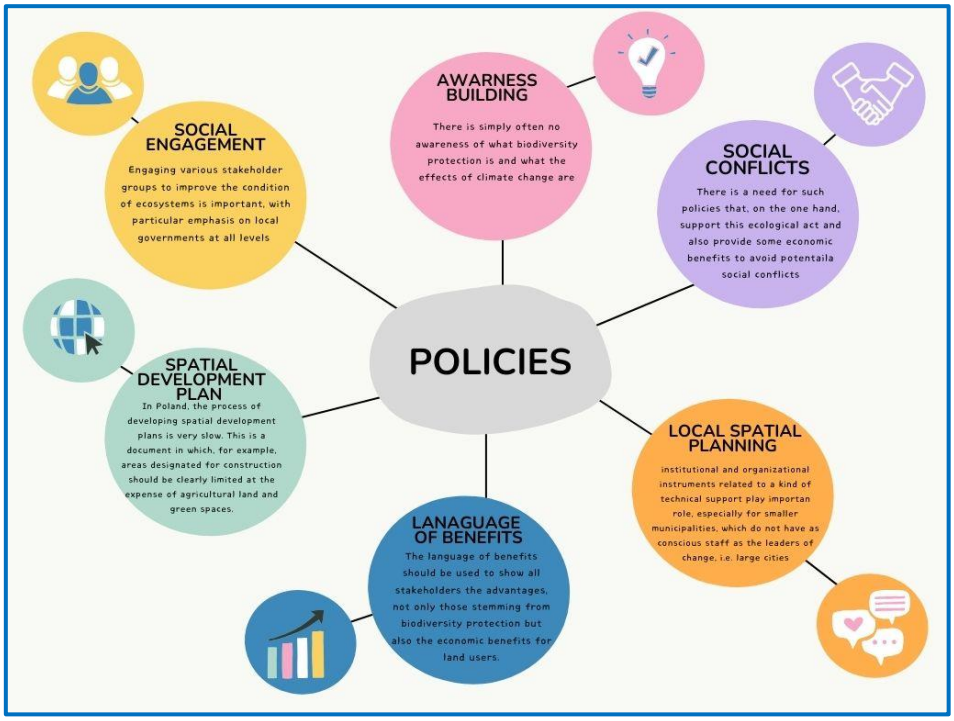
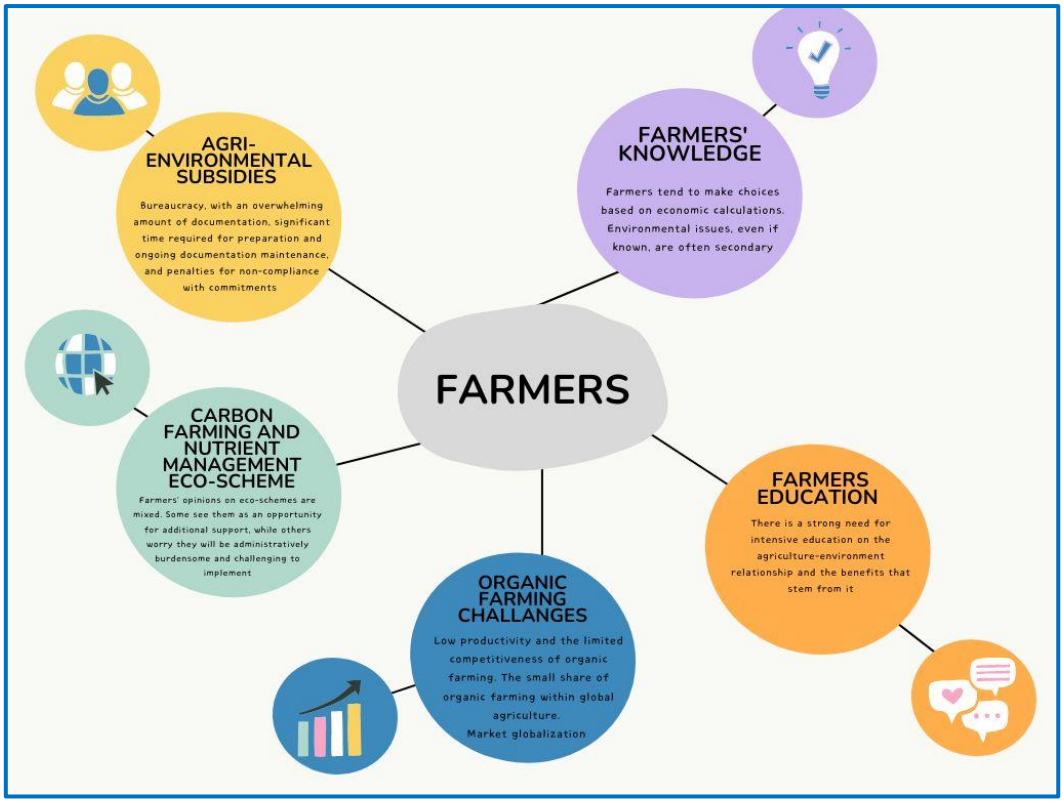
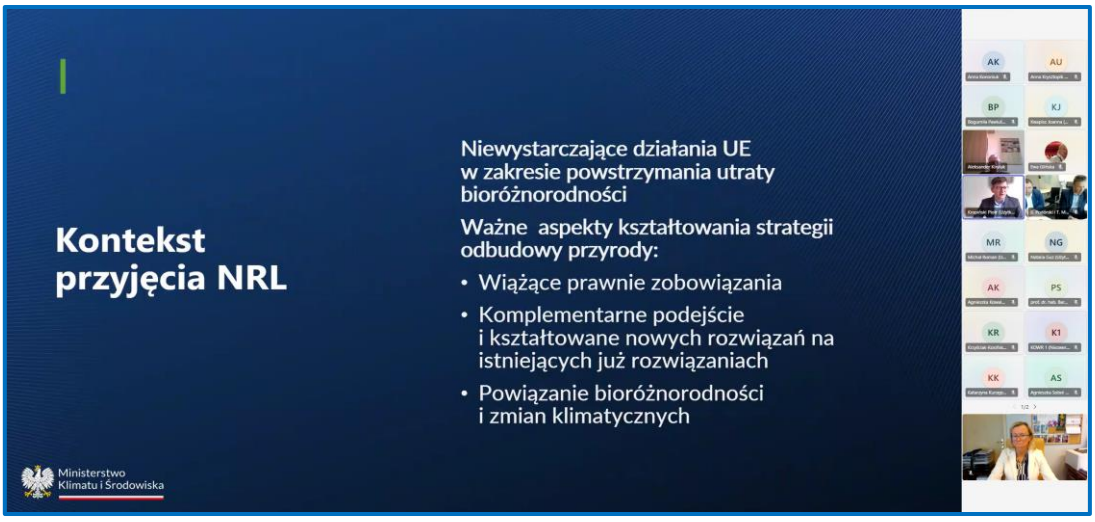


Figure 2. The level of support of the current policies to sustainable land management
Source: own study on the basis of Mentimeter results

The majority of experts indicated that this support exists only to a very small extent (4 responses) or to a small extent (7 responses). Two experts did not know the answer to this question or were not familiar with these policies. Only one expert held the opposing view, indicating that the support of current policies for sustainable land management is significant.




FARMERS
AGRI-ENVIRONMENTAL SUBSIDIES
Bureaucracy, with an overwhelming amount of documentation, significant time required for preparation and ongoing documentation maintenance, and penalties for non-compliance with commitments
FARMERS' KNOWLEDGE
Farmers tend to make choices based on economic calculations. Environmental issues, even if known, are often secondary
CARBON FARMING AND NUTRIENT MANAGEMENT ECO-SCHEME
Farmers' opinions on eco-schemes are mixed. Some see them as an opportunity for additional support, while others worry they will be administratively burdensome and challenging to implement
FARMERS EDUCATION
There is a strong need for intensive education on the agriculture-environment relationship and the benefits that stem from it
ORGANIC FARMING CHALLANGES
Low productivity and the limited competitiveness of organic farming. The small share of organic farming within global agriculture.
Market globalization


Kontekst przyjęcia NRL
Niewystarczające działania UE w zakresie powstrzymania utraty bioróżnorodności
Ważne aspekty kształtowania strategii odbudowy przyrody:
• Wiążące prawnie zobowiązania
• Komplementarne podejście i kształtowane nowych rozwiązań na istniejących już rozwiązaniach
• Powiązanie bioróżnorodności i zmian klimatycznych
Ministerstwo Klimatu i Środowiska

Portugal

Partner organization: Centre for Functional Ecology (CFE), University of Coimbra

Workshop name: Portuguese: Desafios dos usos do solo na resposta às alterações climáticas
English: Challenges in land use management for climate change response
Date: 14th of October, 2024
Format: in person
No of participants: 13
Participant institutions/organizations: Environmental and Nature Conservation NGO; Agriculture & Agroforestry consulting company; Agricultural, food, forestry, sea and rural development sectors consulting company; Academia; Former Secretary of State for Agriculture; Water resources Manager; Agroecology European Association representative; International Association of Students in Agricultural and Related Sciences representatives; Farmers' association representatives.

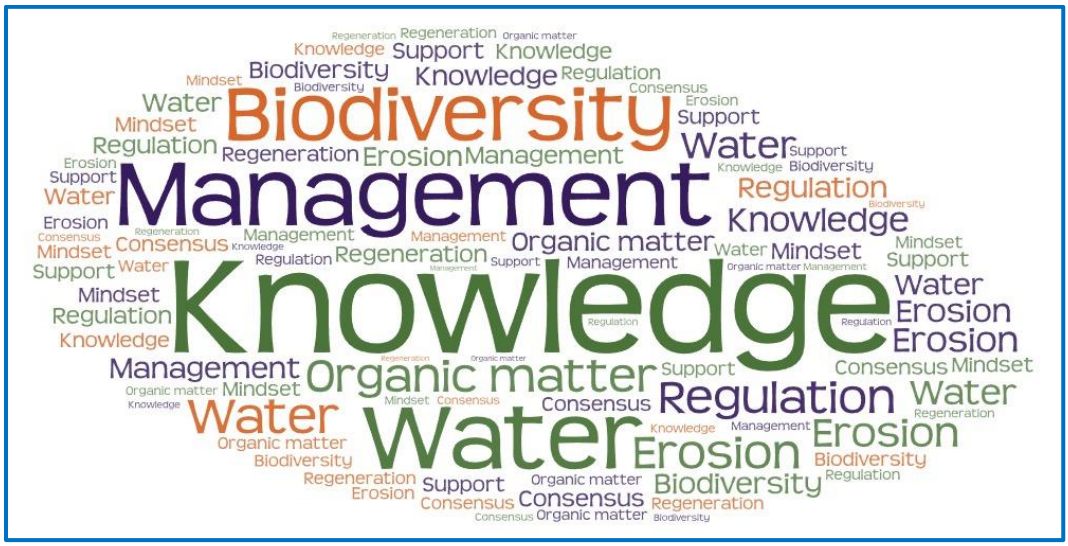
Country profile

In Portugal, agricultural lands, including vineyards, olive groves, and cereal crops, are central to its economy, and land management involves balancing agricultural productivity with environmental sustainability. Traditional farming practices coexist with modern agriculture, yet small-scale farmers struggle to keep up with market demands and environmental regulations. Soil degradation, water scarcity, and wildfires further difficult land management, as do the impacts of climate change on crop viability.

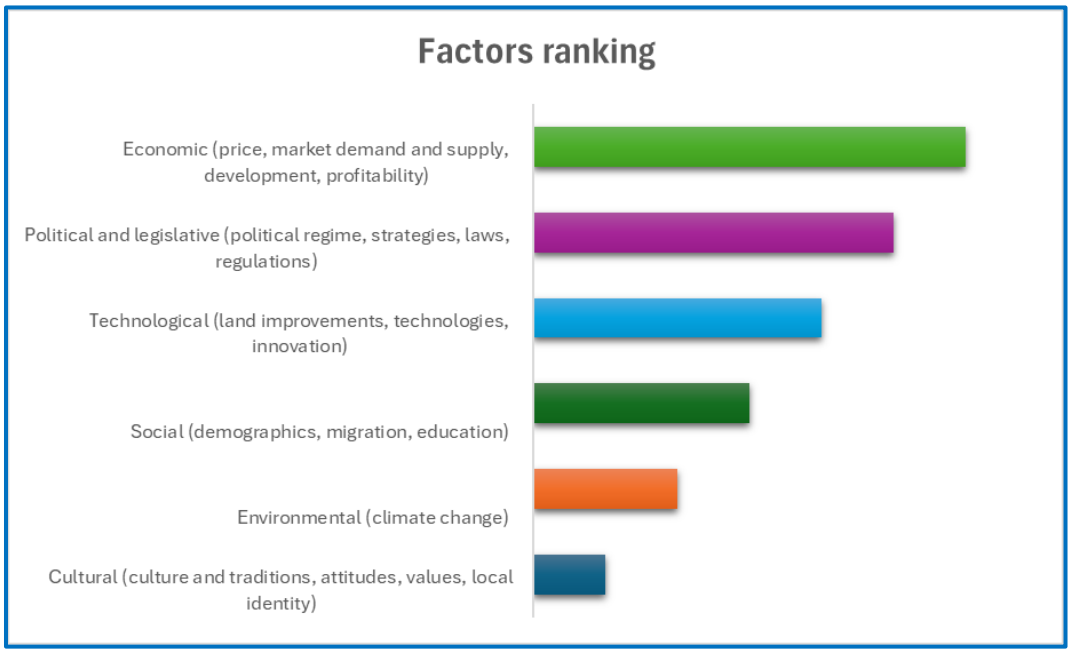
Desertification and prolonged droughts in the Portuguese interior regions reduce agricultural productivity and increase soil degradation, highlighting the need for sustainable water management and drought-resistant crops. Effective water management is thus critical since climate change affects the availability and distribution of water resources, which are essential for agriculture, industry, and domestic use. Besides that, the country's extensive coastline is highly susceptible to rising sea levels and increased coastal erosion.

The increasing frequency and intensity of wildfires demand improved forest management and community awareness. The country has made advances in reducing greenhouse gas emissions through land-use change and forestry practices. However, extreme weather events, such as the devastating wildfires in 2017, have highlighted the increasing risks and vulnerabilities of the Portuguese territory. Furthermore, biodiversity and habitat loss due to climate change impacts highly increased in Portugal, requiring adaptive management strategies to protect, restore and increase the resilience of ecosystems. Addressing these issues requires practical policies that support local farmers, enhance land resilience, and adapt to shifting environmental realities.

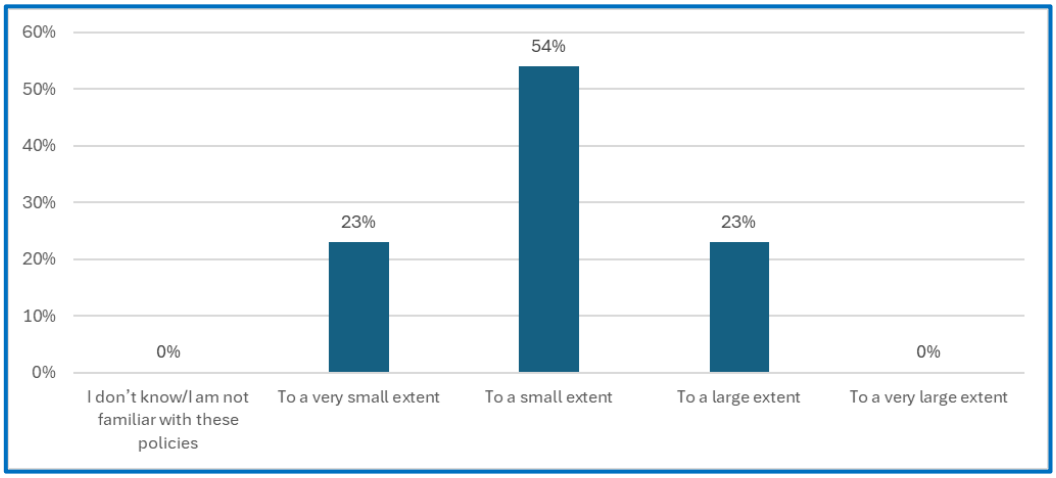
Land sustainability challenges



Factors ranking



Support of the current policies to sustainable land management



Romania

Partner organization: Romanian Academy, Institute of Geography

Workshop name: Present land use and land management challenges and future perspectives
Date: June 13th, 2024
Format: in person
No of participants: 21
Participant institutions/organizations: governmental institutions (e.g. provision of climate services, agriculture, protected areas, remote sensing), **NGOs** (in the field of organic farming), **academia** (e.g., agronomic/sciences research, agricultural economics), **business.**

Country profile

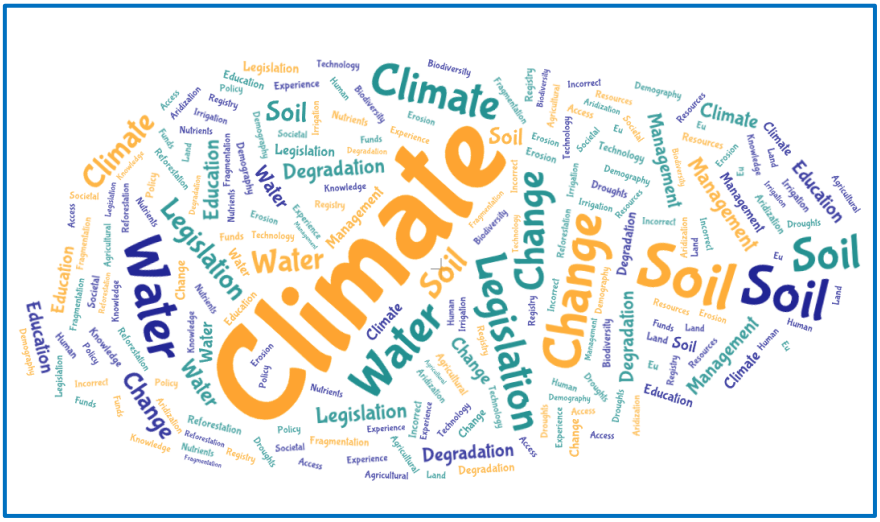
Romania is one of the European countries with important agricultural land resources (0.76 ha agricultural land and 0.49 ha arable land per capita in 2023). The diversity and specificity of the pedo-climatic systems (mountains, hills and plains in almost equal proportions), as well as the general and regional particularities of a social and economic history, made more than 60% of the country's surface covered by *agricultural lands* (arable, pastures and hayfields, vineyards and orchards), distributed in every landform unit (Geografia României vol. II, 1984).

The last decades (post-communist period) was charecterised by the radical political, socioeconomic and institutional transformation that starts widespread agricultural and land-use/cover changes (Kümmerle, 2008; Kuemmerle et al., 2009; Bălteanu and Popovici, 2010; Griffiths et al., 2013; Popovici et al., 2013; Kucsicsa et al., 2019), primarily influencing property rights and the decision-making process concerning the management of natural resources. In this period, the collective and state property was replaced by private property, through decollectivization and privatization. The main effects of these ownership changes include the expansion of private property to over 94% of the total agricultural area, but also the sharp fragmentation of agricultural land and the formation of a very large number of small farms (more than 99% being under 5 ha) (Bălteanu et al., 2004, 2006; Bălteanu and Popovici, 2010) with insufficient financial resources, owned by elderly people, many of whom had no agricultural experience. Furthermore, large areas of permanent crops and arable lands in the less productive regions were abandoned, and most land improvements works, especially irrigation, were degraded or abandoned. After 2007, the agricultural land use changes were influenced by the Romania's *EU* accession (2007), which involved the fulfillment of certain requirements necessary for the adoption and implementation of the Common Agricultural Policies (Popovici et al., 2013, 2018). Moreover, within the EU framework, Romania benefited from irredeemable funds for agricultural and rural development, which made up a new evolution framework for the development of agriculture.

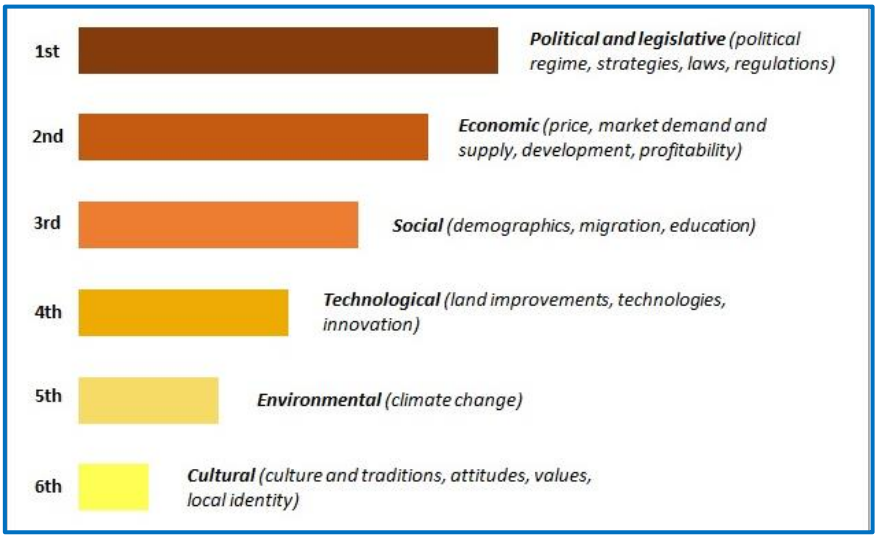
Romanian agriculture still faces a sharp fragmentation of agricultural land, especially in the plateau and hill regions, but also in the less productive plain regions. However, in the last 10-15 years, the fragmentation of agricultural land has decreased, especially in the plain regions of the south, southeast and west of the country. In these areas, the lands were merged into large agro-industrial holdings, with Romanian or foreign capital, in which modern and competitive agriculture is practiced, and the yield of agricultural crops is high, above the national average. However, in the opinion of many researchers in the field, the increase in the very large territorial size of farms does not represent a

factor for the sustainable development of agriculture. Other feature of agriculture is represented by the low degree of mechanization of agricultural works and the difficulty of applying new production technologies within small individual farms; low productivity and quality caused by lack of financial resources, insufficient use of inputs, lack of agronomist specialists, as ell as inadequate agricultural infrastructure. The lack of irrigation systems and the degradation of other land improvement systems make agricultural production highly dependent on climatic conditions, especially in drought-prone areas. This is because, after 1990, climate variability increased by climate change played an important role in the transformation and evolution of agricultural lands, especially by exacerbating the effects of extreme events (*e.g., drought, desertification, hailstorms and floods*) and by expansion of affected areas (Sandu et al., 2010; Busuioc et al., 2015; Micu et al., 2017).

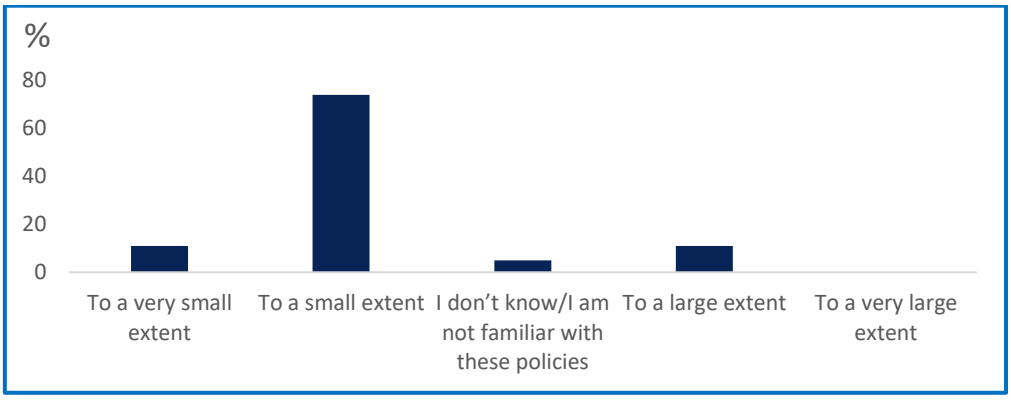
Land sustainability challenges

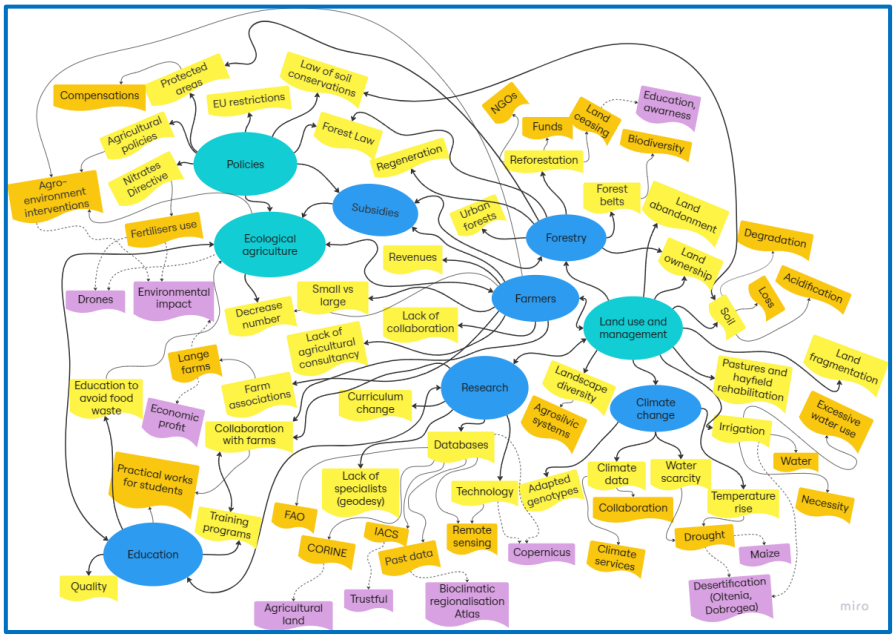


Factors ranking

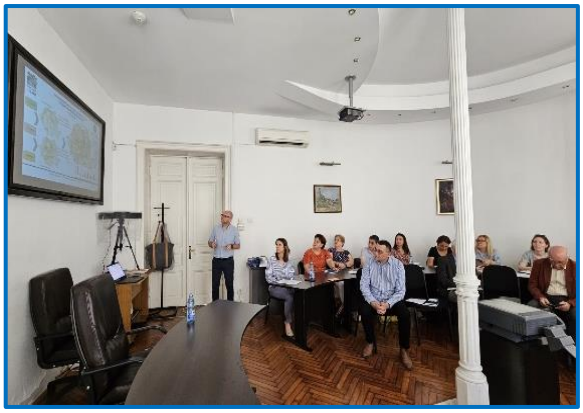


Support of the current policies to sustainable land management





Conceptual map of the discussions during the Mirror Workshop in Romania



Slovakia

Partner organization: Slovak University of Agriculture in Nitra (SUA in Nitra)

Workshop name: Preparation of the new agri-policy and adaptation of the Strategic Plan of the Common Agricultural Policy (expert workshop)

- A day for soil (seminar with practical demos)
- Innovations for healthy landscapes and responsible farmers (national dialogue on agriculture in Slovakia)

Date: 10th October 2024, 17th October 2024, 7th November 2024

Format: in person and hybrid events at SUA in Nitra

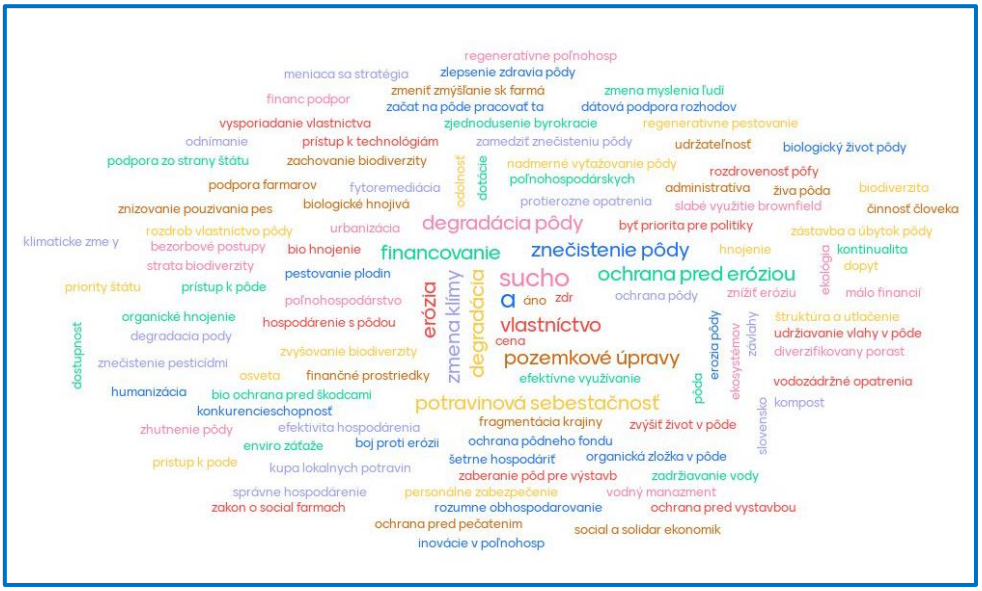
No of participants: 110, 35, 75

Participant institutions/organizations: research and development, consultancy, academic sector, NGOs (ecological, environmental), agriculture and forestry (land users), state/public administration (ministries and their agencies - agr., environm.), Permanent Representation of the SR to the EU, associations of farmers, chamber (agr., food), industry (agrifood), banking sector (with products for farmers), cluster, media.

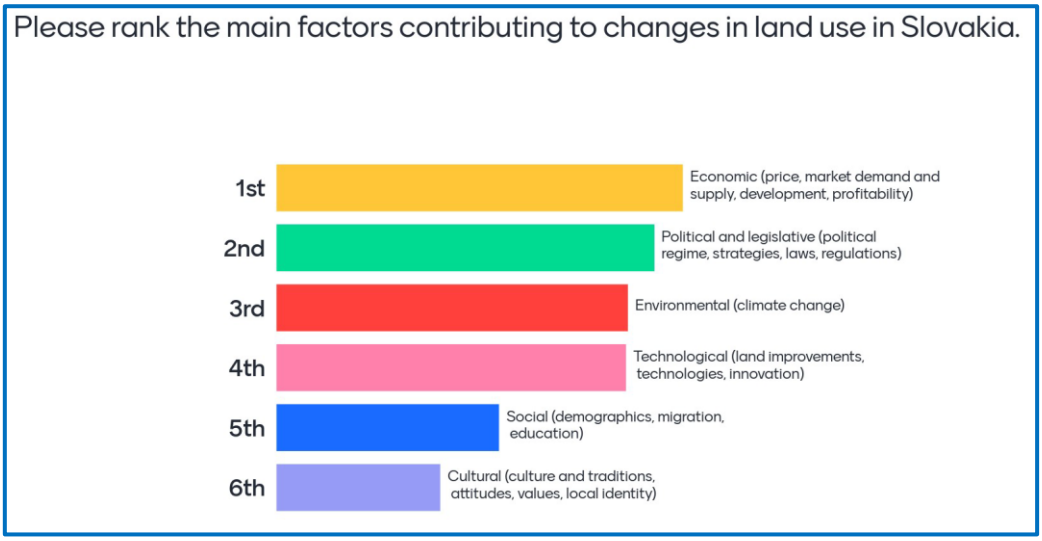
Country profile

Land sustainability challenges

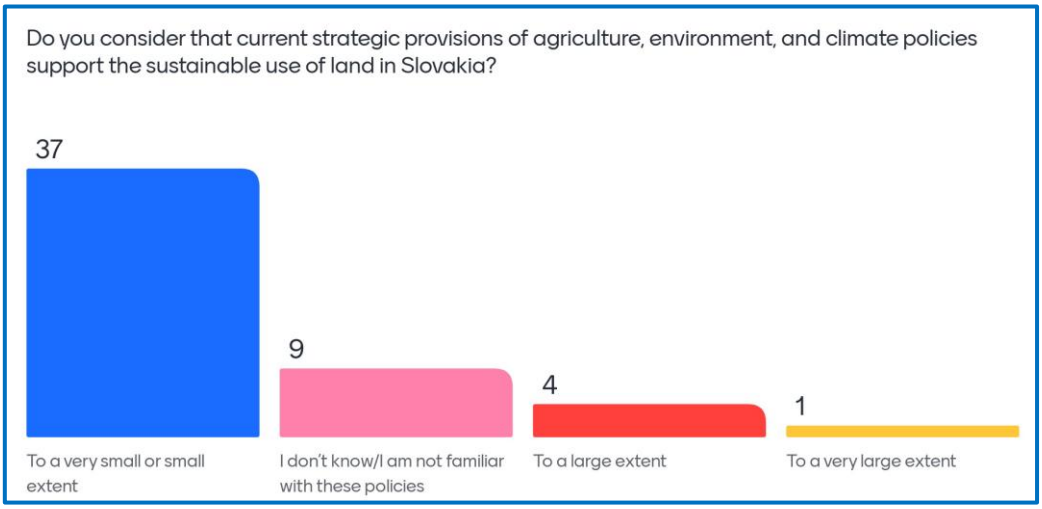
Most common terms: drought and erosion, land reparcelling/land ownership/access to land, degradation and pollution, climate change, financing.

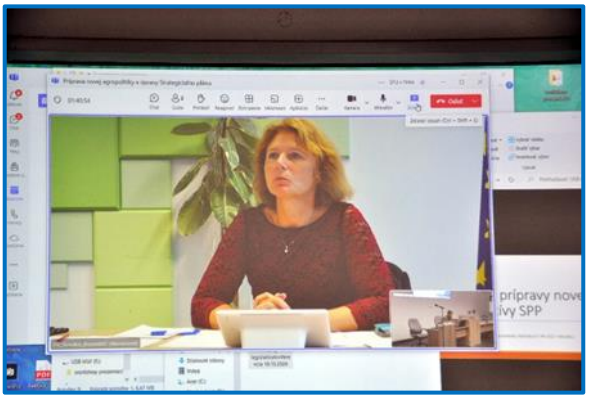


Factors ranking



Support of the current policies to sustainable land management





A day for soil **(seminar with practical demos)**
https://uniag.sk/sk/aktualne-informacie/na-odbornom-programe-dna-pre-podu-v-arborete-mlynany-sa-podielal-aj-vpp