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InBestSoil

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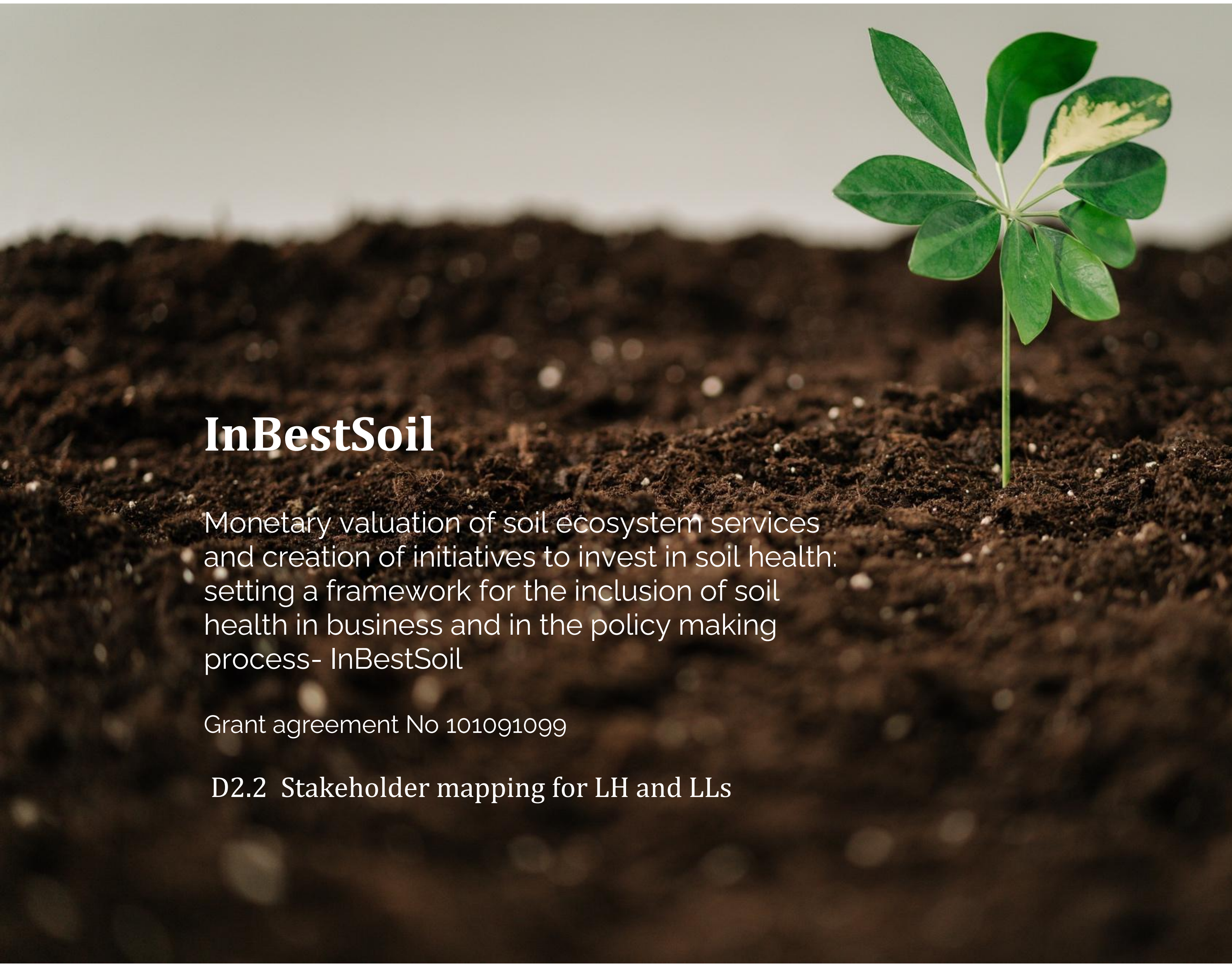

InBestSoil

Monetary valuation of soil ecosystem services and creation of initiatives to invest in soil health: setting a framework for the inclusion of soil health in business and in the policy making process- InBestSoil

Grant agreement No 101091099

D2.2 Stakeholder mapping for LH and LLs

Stakeholder mapping for LHs and LLs

Summary

This document constitutes the Deliverable ***D2.2. Stakeholder mapping for LHs and LLs and it*** is the second output of the Task 2.1 *Analysis and mapping of stakeholders for each LL and LH* in the frame of WP2 *Stakeholder communities for co-creation, co-innovation, and co-learning*. The deliverable collects the main insights and context narratives for the 7 LHs and 2 LLs for the project activities, as well as a preliminary approach to stakeholder groups´ identification and engagement for each of these sites. This deliverable is an update of deliverable D2.1, and it has been developed in consultation with all consortium partners, especially with LL/LH coordinators.

The objective of InBestSoil is to **co-create a framework for investment in conservation and recovery of soil health**, by developing an economic valuation system of the ecosystem services delivered by a healthy soil and the impacts of soil interventions, and its incorporation into business models and incentives. This will allow for public and private organisations to provide economic value to their actions over soil health, codesign strategies with local stakeholders, and work collectively to deliver national and EU policy ambitions. InBestSoil will provide data, evidence, tools, and models to assess how investment in soil health can contribute to the transition to a long-term resilient and sustainable use of soil. The focus is on 7 LHs and 2 LLs that provide a total of **9 study areas across 4 biogeographic regions in Europe** (Boreal, Continental, Atlantic, Mediterranean), and different land uses (agriculture, forest, urban, mining). These constitute models for cocreation and co-design (multi-actor approach, responsible research and innovation and open science). InBestSoil is a 48-month project that started in January 2023, and it includes 19 partners from 10 European countries.

WP2, *Stakeholder communities for co-creation, co-innovation, and co-learning* will cover the entire project duration and its **main objective is to create and strengthen stakeholder communities along the project case studies** as central hub for the performance of all other WPs. WP2 is divided in four tasks to achieve the following specific objectives: [1] engage and involve a wide variety of local, regional, national and European stakeholders including companies, public authorities, investors and civil society in investments in soil health; [2] establish short- and long-term collaboration schemes and platforms for the effective co-creation, co-innovation and co-learning process and sustainability of the project by dynamizing LH communities and building LLs around them; and [3] implement participation, co-design and co-creation methodologies to fully integrate key stakeholders knowledge, perceptions and interests in all the project activities and beyond.

Assessing the economic value of ecosystem services provided by soil, as well as current initiatives in place for improving soil health, will need a wide variety of stakeholders to determine the most successful factors that look for an equilibrium across all actors from the value chain, including civil society. Likewise, proposing new business models and policy recommendations or incentive frameworks will also benefit from the different perspectives that a diversity of stakeholders can bring to the table. Therefore, WP2 will **establish the most appropriate stakeholder groups that influence or are impacted by each LL/LH** of the project to enable effective co-creation initiatives to share information, upskill, and advance the general knowledge on soil management and investment models in the future. The related ***D2.3 co-creation plan*** will be delivered in M20.

Deliverable Number	**Work Package**
D2.2	WP2
Lead Beneficiary	**Deliverable Author(s)**
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	InBestSoil LHs and LLs
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Dissemination Level	PU	Public	x
	CO	Confidential, only for members of the consortium	

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Introduction and scope

The deliverable D2.2 is the second output of task 2.1, *Analysis and mapping of stakeholders for each Lighthouse (LH) and Living Lab (LL)* in the frame of WP2, and it constitutes an update on the previous deliverable, D2.1. Task 2.1 is led by ZABALA and involves all project partners.

The main objective of task 2.1 is to identify and map stakeholder communities along the project´s LHs and LLs, to **ensure that the economic value proposition, business models, and incentives framework proposed by InBestSoil meet local context** needs. In addition, synergies with sister projects funded under the topic *HORIZON-MISS-2022-SOIL-01-03: Soil biodiversity and its contribution to ecosystem services*, and other EU projects related to soil health management will be sought.

Within this task, ZABALA, together with project partners, performed a **preliminary identification of relevant stakeholders** related to each LH and LL involved in the project (D2.1), focusing on stakeholder group profiles and the type of knowledge they can bring or request from the project. In the second phase (D2.2), these stakeholders have been **categorised and mapped** according to their interest in or influence on the project.

To better understand the potential interest and influence of stakeholders in relation to InBestSoil, high-level research on the **context narrative for each Lighthouse and Living Lab** has been carried out. These includes key attributes and values such as socioeconomic, cultural, and historical aspects relevant to each location and within the Mission Soil framework.

This analysis will be useful to carry out task 2.2 *Development of key stakeholders' co-design and co-creation plan and implementation roadmap* by understanding the different stakeholder groups´ contexts in each location and best adapting co-design and co-creation activities to stakeholders´ needs, as well as aligning these with Mission Soil objectives.

Relation to other project activities

WP2 shares objectives with all other project WPs as its main objective is to support the stakeholder engagement needs of the project to deliver on its expected results. To this aim, a preliminary stakeholder engagement needs roadmap has been developed, that includes all the expected stakeholder interactions needed by all WPs of the project:

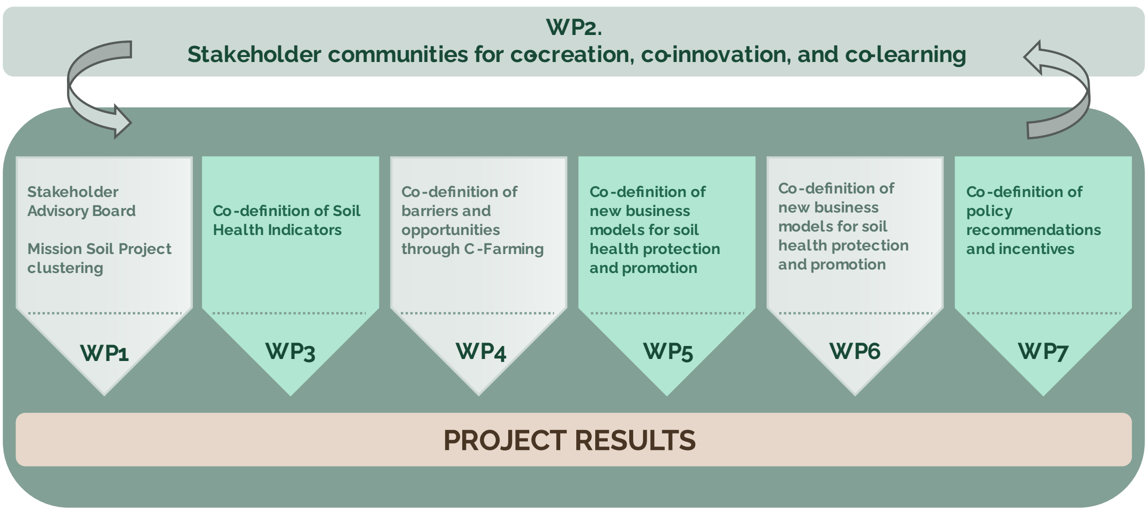


Figure 1. Stakeholder engagement activities and interactions included in the project WPs.

Mission Soil: A Soil Deal for Europe

A Soil Deal for Europe (Mission Soil) is a major instrument to co-design, assess, monitor, and implement actions to restore and protect soil so that it can continuously provide benefits to society and the planet. The Mission not only aims to maximize the benefits of soil health conservation and restoration in the EU, but also to minimize the adverse effects of land use outside the EU, and it will largely contribute to the overall goals of the European Green Deal.

The Mission's **specific objectives** include:

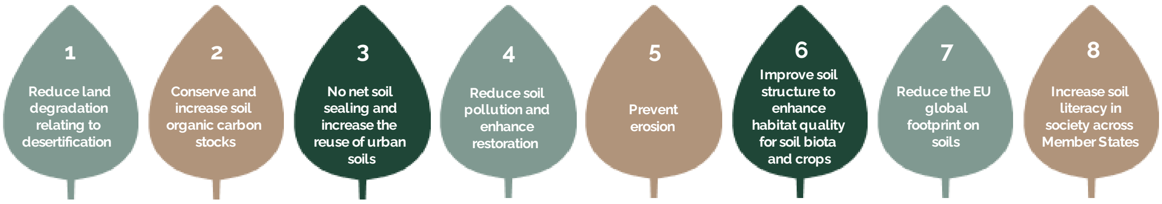


Figure 2. InBestSoil´s representation of Mission Soil specific objectives as indicated in the implementation plan[1].

The Mission will be implemented through:

- A transdisciplinary research and innovation (R&I) programme which includes a social science component to fill knowledge gaps and develop solutions for soil health. The Mission will address all types of land use in rural and urban areas.
- A network of 100 Living Labs (for experimentation) and lighthouses (for demonstration) to accelerate the co-creation and uptake of solutions across various settings in a diversified geographic and socio-economic context.
- A robust, harmonised EU framework for soil monitoring and reporting.
- Communication and citizen engagement activities to increase soil literacy across society.

To achieve these ambitious goals the Mission Soil wants to establish a **well-structured and participatory Governance structure** to which InBestSoil aims to contribute through its stakeholder engagement approach:

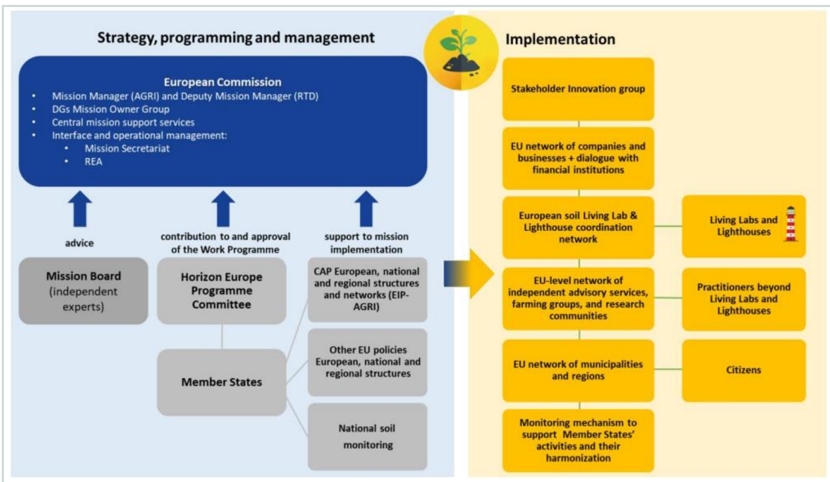


Figure 3. Mission Soil Governance structure (from Mission Soil Implementation Plan).

[1] soil_mission_implementation_plan_final_for_publication.pdf (europa.eu)

InBestSoil will establish connections with strategy, programming, and management bodies as well as with stakeholders involved in the implementation of the Mission (Figure 3). The project counts on 7 LHs and 2 LLs, whose experience will provide the essential knowledge to set up the field to facilitate the development of operational frameworks for additional LLs to cover the areas of influence of the rest of LHs.

The expected growth in the community of stakeholders collaborating in the LHs will allow scaling up the soil intervention techniques, fostering the creation of new satellite case studies around the LHs that will allow the development of operational frameworks for new LLs (WP2).

Stakeholder and citizen engagement in Mission Soil

The European Commission has promoted the Mission Soil and its objectives to interested stakeholders and citizens through several initiatives, thus facilitating their involvement and engagement in the Mission. **Awareness of soil issues is key to ensuring active position/participation and involvement** on the part of interested parties in activities and initiatives related to soil health.[2]

Stakeholder engagement is an essential pillar of the mission´s added value that proposes a novel approach to R&I for impact. This is based on open science and interactive, **participatory innovation with strong stakeholder and citizen engagement** (through Living Labs and lighthouses). By implementing R&I activities, local testing grounds, monitoring and training activities in joint up manner, the mission will act as a broker of innovation and will go well beyond what could be achieved within single parts of Horizon Europe or other instruments at EU level. Also, the mission is expected to mobilise actors across society in ways that would not happen otherwise. All these aspects are contemplated within the Mission Soil Implementation plan operational objectives which InBestSoil aligns completely with:

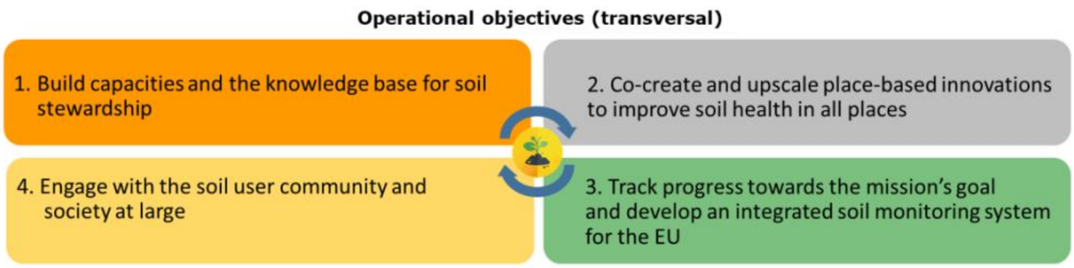


Figure 4. Mission Soil Operational Objectives as set out within the implementation plan.[1]

The term 'stakeholder' has its origin in organisational theory and strategic management: according to literature, stakeholders may be defined as "any group or individual who is affected by or can affect the achievement of an organization's objectives" (Freeman, 2001, p.3)[3], "all parties who will be affected by or will affect [the organization's] strategy" (Nutt & Backoff, 1992, p.439)[4] or "the term refers to persons, groups or organizations that must

[2] European Commission, Directorate-General for Research and Innovation, Communication and citizen engagement initiatives in line with the Horizon Europe Mission A Soil Deal for Europe – Report on dissemination and exploitation practices in Member States and associated countries, Publications Office of the European Union, 2022. https://data.europa.eu/doi/10.2777/704413

[3] Freeman, R. E. and McVea J. (2001). A stakeholder approach to Strategic Management. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=263511

[4] Nutt, Paul C., and Backoff, Robert W. (1992). Strategic management of public and third sector organizations: A handbook for leaders. Jossey-Bass

somehow be taken into account by leaders, managers and front-line staff" (Bryson, 2004, p.22)[5].

Within WP2, we have identified three types of stakeholders to consider during the lifetime of the project and beyond, based on the type of engagement expected:

- **Co-creating the results:** stakeholders from the project use cases will collaborate with researchers in developing the project's results. These activities will be facilitated through the co-creation plan (D2.3), which describes the co-creation activities to be carried out during the project lifetime.
- **Mission soil stakeholders for knowledge exchange**: engagement with Mission Soil projects and in particular with sister projects to share knowledge and collaborate in various initiatives such as the Mission Soil Platform: Communications & Stakeholder Engagement Cluster.
- **Dissemination of project progress and results:** stakeholders interested in project results and the general public with whom project progress and results will be disseminated, primarily managed through Work Package 7 (WP7).

Thus, the identification, mapping, and consideration of all stakeholders in soil-related matters are of utmost importance. Recognising the significance of their perspectives, the engagement of diverse stakeholders is crucial for comprehensive decision-making processes. By involving government bodies, local communities, scientists, environmental organisations, farmers, and industry representatives, we can foster collaboration, knowledge sharing, and collective action towards sustainable soil management. **InBestSoil believes that each stakeholder brings unique expertise, interests, and concerns to the table, enriching the dialogue and enabling the development of holistic solutions that address the diverse challenges faced by soils.** By actively involving all stakeholders, we can promote transparency, equity, and accountability, ensuring that decisions regarding soil health are well-informed, balanced, and sustainable in the long term.

[5] Bryson, John M. (2004). What to do when stakeholders matter: stakeholder identification and analysis techniques. Public management review 6.1 (2004): 22

InBestSoil LH and LLs: A context narrative

Soil health in Europe

Over 60% of European soils are currently in an unhealthy state and scientific evidence shows that soils are further degrading due to unsustainable management of the land, sealing, contamination and overexploitation, combined with the impact of climate change and extreme weather events. Degraded soils reduce the provision of ecosystem services such as food, feed, fibre, timbre, nutrient cycling, carbon sequestration, pest control or water regulation. The loss of these essential soil ecosystem services costs the EU at least 50 billion euro per year[6]. However, **activities that affect soil are not reported** as such in companies' environmental reporting standards, or appear mixed in with other statistics (Davies, 2017). To address soil health issues, the business sector, policymakers, public administration, and scientific community must join efforts to develop practices and policies that recognize and acknowledge the importance of soil for sustaining livelihoods, upholding biodiversity, and regulating earth's climate.

InBestSoil´s role in improving Soil Health

InBestSoil will define the monetary value of ecosystem services delivered by a healthy soil, analyse and upscale current successful business models, co-design with a wide range of stakeholders' new business models and initiatives based on the value of soil health, and propose appropriate incentives. This will lead to the creation of products, services and value chains that are less harmful to the soil. So far, soil health has never been conceived as an element for business models and investments.

To achieve this, InBestSoil has selected 7 existing Lighthouses (LH) and 2 Living Labs (LL, in different maturity stages) covering four different land uses (agricultural, forestry, urban and mining) across four different biogeographic regions in Europe (Boreal, Continental, Atlantic and Mediterranean). This diversity of use cases will enable project results to be replicable and adaptable to multiple areas across the EU.

The 7 LHs (forests, urban plots, and former mining areas) are examples of demonstration solutions and engagement of practitioners and key stakeholders to accelerate the innovation uptake. Each of the 2 LLs includes between 10 and 20 farms that operate at a subregional level, in which experiments involving land managers, farmers, farmers' organisations, businesses, scientific community, policymakers, and industries, among others, are coordinated to test, monitor, and evaluate practical solutions to develop business models with interventions that enhance soil health.

Context narratives

This section provides the main insights and context narratives for the project LHs and LLs that will act as use cases for the InBestSoil project activities. The map of LL and LH presents the location and the main goals for each of them (Figure 5).

[6] Soil health (europa.eu)

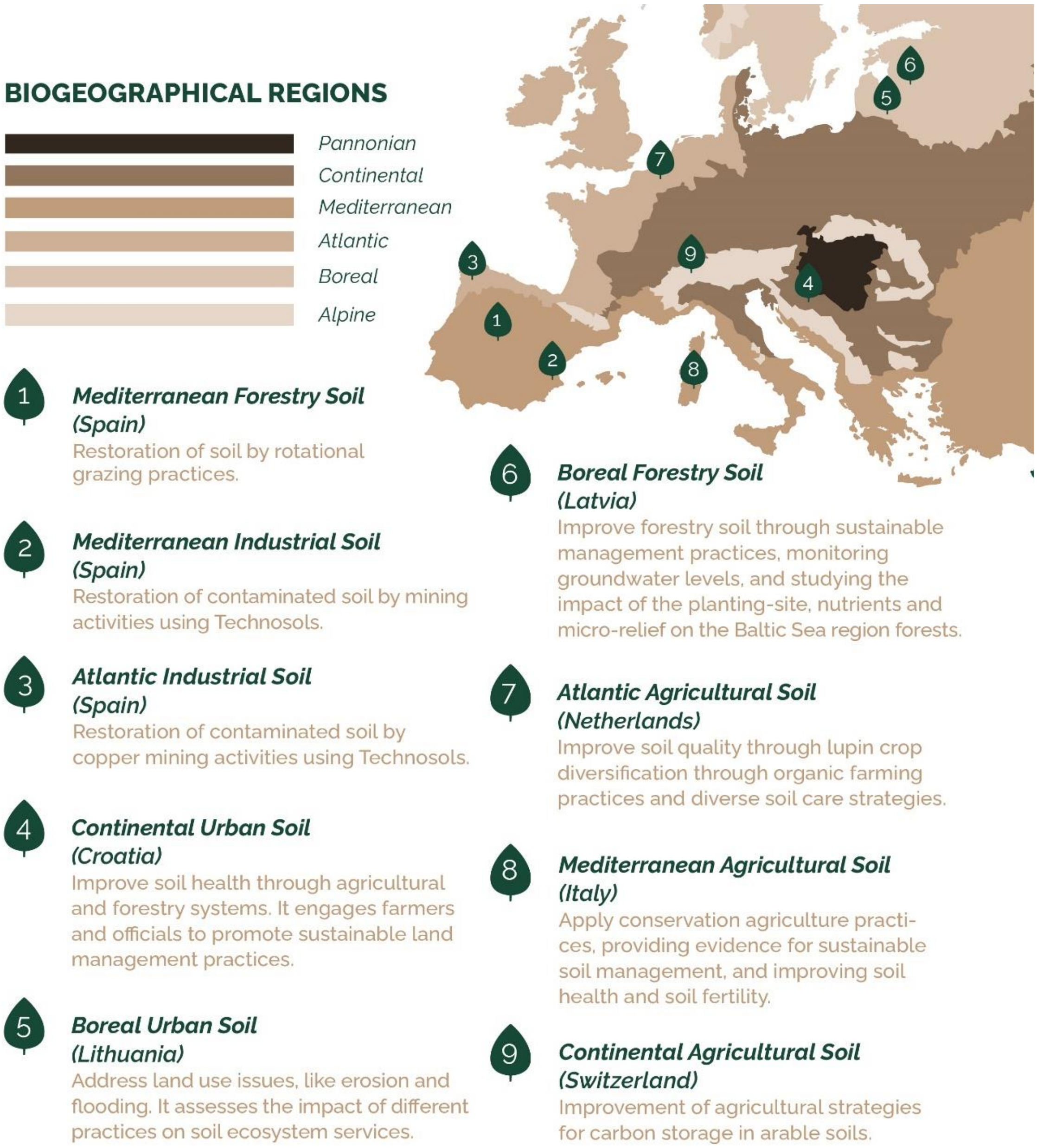


Figure 5 - Map of InBestSoil Lighthouses and Living Labs.

A summary of the main characteristics (location, soil type, land use, challenges addressed, and proposed solutions and opportunities) of each LH and LLs is presented in table 1:

INBESTSOIL LH AND LLS

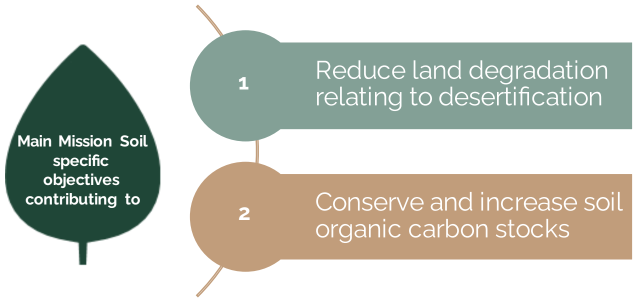
LH/LL	Location	Soil type	Land use	Challenges addressed	Since	Proposed solutions / Opportunities
LH1 - Dehesa El Baldío de Talaván	Extremadura, Spain	Mediterranean forestry (pasture) soil	Livestock farming, Agriculture	Poor land use and loss of fertility	1993	Carbon storage opportunities in forest soils Increased fertility and quality f soil through herbivores "carbon pump" and "rotational grazing"
LH2 - Mining district of Cartagena - La Union	Murcia, Spain	Mediterranean industrial soil	Old mine for Fe, Pb, and Zn extraction	Environmental impact caused by the waste produced by mining and metallurgical activities has resulted in marked negative effects on soil, water resources (surface, groundwater, and marine water), landscape, atmosphere, and biota.	1991	Creation of artificial soils (Technosols) applying the aided phytostabilization technique.
LH3 – El Touro mine	Galicia, Spain	Atlantic Industrial soil	Old copper mine	Profound degradation of the environment, lack of vegetation and soil cover, rapid oxidation generating a hyper-acidic mine drainage which contaminates the nearby rivers.	1989	Restoration using artificial soils: technosols
LH4 – Peri urban soils Zagreb	Zagreb, Croatia	Continental Urban soil	Forest, Apple Orchard, Abandoned agricultural land, Grassland	Overexploitation, soil abandonment, compaction, and flood risk near urban areas.	1991	Promoting sustainable natural processes: mulching, low soil disturbance, maintaining vegetation cover
LH5 - Baltupiai urban gardens	Vilnius, Lithuania	Boreal urban soil	Urban gardens, recreation	Poor land use, and risk of soil erosion and flooding in urban areas.	2001	Flood regulation, Erosion regulation, Food production, Carbon sequestration, Recreation
LH6 - Mežole Forest	Vidzeme, Latvia	Boreal Forestry soil	Forests, recreation area	Diverse soil organic matter content, Unbalanced soil nutrient content, Soil acidification, Soil erosion on slopes.	2001	Forest fertilization experiments, Forest regeneration on slopes and lowland parts, Natural and human promoted afforestation
LH7 – Atlantic Agricultural Soil	Betuwe, Netherlands	Atlantic agricultural soil	Agriculture	Reduced soil fertility, biodiversity and ecosystem services and need to extend crop diversifications.	2008	Minimize the time in which the soil is bare; Alternative organic fertilization; developing business cases around N-fixing crops;
LL1 – Campidano plains & other Sardinian areas	Sardinia, Italy	Mediterranean Agricultural soil	Agriculture	Reduced soil fertility, biodiversity and ecosystem services associated with conventional agriculture.	2003	2 Reference Experimental Sites 9 Experimental sites Regional Conservation agriculture
LL2 - Climate protection through humus build-up Baselland Canton, Switzerland	Basel land Canton, Switzerland	Continental agricultural soil	Agriculture	Intensive agriculture depletes SOM and increases the risk of soil erosion and loss of soil biodiversity.	2021	2 Reference Experimental Sites (selected among 10) 15 Experimental sites (selected among 55) Regional C-farming + C-credits

Table 1: Summary of InBestSoil LH and LLs characteristics.

LH1. Mediterranean Forestry Soil - Dehesa El Baldío de Talaván (El Baldío)

This chapter presents the general information of LH1; LH representatives, geoclimatic description, socioeconomic description, identified challenges, proposed solution and results observed.

Summary



Coordinator partner	Fundación Global Nature & Actyva
LH name (location)	Dehesa El Baldío de Talaván
Region	Talaván (Cáceres), Extremadura
Country	Spain
Area (Ha)	Sampling area: 5,94 ha / Total: 232 ha
Soil health challenges	• No vegetative growth all year round • No humidity and temperature conditions for the necessary microbiological activity • Continuous degradation

Figure 6: Summary of general information, LH1.

LH Representatives

Fundación Global Nature (FGN) is an NGO for nature protection and conservation since 1993, based on technical rigorousness, ethical compromise, and innovation, distributed in 3 main blocks: habitat and species conservation, agricultural sector sustainability and corporate sustainability. FGN works with the quadruple helix primary sector and the local community, with administrations, science, universities, and large companies, for creating alliances for the sustainable use of biodiversity and the natural heritage. FGN bridges theory and practice developing strategies and plans with fieldwork and applied projects, working actively on the ground, through land stewardship agreements, stakeholders' involvement, and monitoring key indicators, to protect habitats and species.

The ACTYVA Cooperative Society is an initiative that arises to facilitate the generation of productive, alternative and solidarity economy projects, and the connections between them and with their immediate environment to reactivate relationships and exchanges at the local level in Extremadura. ACTYVA seeks to be an economic activation network to work at all levels and in all sectors, create synergies and advance models and comprehensive self-management solutions that generate benefits (personal, social, and environmental) for the environment and the community where they develop.

These two organisations have joined forces within the InBestSoil project to showcase the exemplary performance of the **InBestSoil Lighthouse 1 (LH1) - El Baldío de Talaván**, a space at the service of biodiversity.

Geoclimatic description

The term `dehesa' has many meanings. Nowadays, the most widely accepted definition is that of an agrosilvopastoral system developed on poor or non-agricultural land and aimed at extensive livestock raising**.**

The Dehesa El Baldío de Talaván is a property located between the Mediterranean mountain of Monfragüe and the plains area of the Llanos in Cáceres, spanning over 232 hectares of land, which has been managed by Fundación Global Nature since 1993.

The dehesa, a unique ecosystem in the Iberian Peninsula, is the focus of work at El Baldío, aimed at enhancing knowledge through partnerships and cross-cutting projects.

In this collaborative space, livestock farming, agriculture, and nature conservation coexist, promoting a sustainable business model for agriculture production and soil conservation. The exploration of new practices and approaches in the agri-livestock sector carried out in El Baldío, such as rotational grazing, enclosure rotation, and transhumance, have yielded positive outcomes. Collaborative work is ongoing, involving technical and educational visits, participation in various research projects led by FGN, and special attention to the preservation of native breeds.

Figure 7. Geographic location of LH1.

Socioeconomic description

Agricultural activity is the main economic sector in Talaván: in 2006, the percentage of employees in the primary sector was 35.59% of the population (table 2), which represents about a third of the active population.

In 2004, farms dedicated to agriculture accounted for 76.5% of the total. Most of them were dryland farming (74.9%). The main crops are olive trees (44.8%), cereals, especially oats (25.8%), forage crops (20%) and wheat (9.4%). Most of it is extensive agriculture.

EMPLOYMENT BY SECTOR	% of population
Primary sector	35,59%
Construction	22,37%
Industry	5,76%
Tertiary sector	35,93%

Table 2. Employment percentage per sector LH1 area (Talaván, Extremadura, Spain).

Identified challenges.

In the EU, agriculture occupies more than 47% of the territory, and approximately 50% of European species depend on agricultural habitats. Such high natural value areas can generate social and economic value if well managed.

Soils in a Mediterranean context, such as in El Baldío, face extreme weather conditions such as high temperatures and water scarcity. Edaphic trophic dynamics in these contexts are impacted by:

- No vegetative growth all year round.
- No humidity and temperature conditions for the necessary microbiological activity.
- Continuous degradation.

In this context, Herbivores play a key role into maintaining these parameters at appropriate levels by activating the decomposition circuit of nutrients and microorganisms necessary for a healthy soil. Therefore, El Baldío implements grazing at a strategic level to:

- Preserve a high natural and agricultural value area by protecting endangered species.
- Protect species and biodiversity dependant on good management practices of the habitat.
- Direct interventions that generate natural, social, and economic value.

Proposed solution

“The Carbon Pump” is the proposed solution.

“The Carbon Pump” (figure 7) with herbivorous animals emulates the operation of a pumping system to increase the availability of carbon and nutrients in the edaphic cycle dynamics:

- Phase I: grass growth, where the roots are the main contribution of carbon to the system.
- Phase II: herbivores eat the grass, thus activating a second phase of redistribution and drainage of the "pump", where the dead roots promote decomposition mechanisms that transform the residues into organic carbon.

The new recharge phase is activated when the increased availability of resources promotes new growth. The management of grazing pulses is essential to favour the charge and discharge cycles of the Carbon Pump and thus maintain the balance of the system.

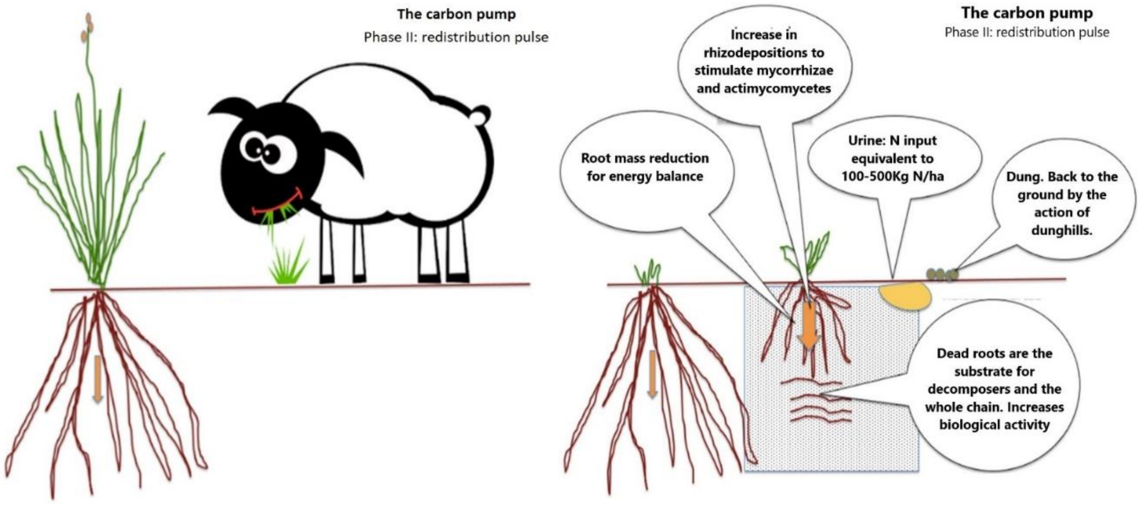


Figure 8. Grazing management through the "Carbon Pump" in LH1.

The impact of the Carbon pump is increased when is combined with "rotational grazing" (figure 8), a grazing management system that mimics the movements of big flocks of wild ungulates, generating high intensity grazing during a short period, a strong impact on pasture and soil, followed by sufficient recovery periods.

The "rotational grazing" approach leads to:

1. Lower input costs.
2. Increased production and quality of graze.
3. Improvement of soil fertility and carbon sequestration levels.
4. Increased natural regeneration of trees.
5. More effective nutrient and water cycles.
6. Improvement on animals´ health.

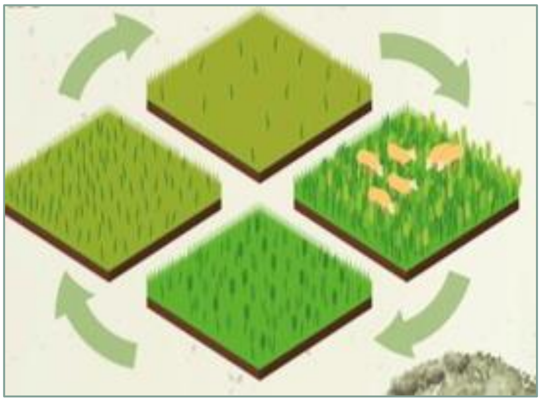


Figure 9. Rotational grazing in LH1.

Within this approach, the key principles for soil conservation in El Baldío are as follows:

- Animals don't choose what they eat.
- Animals controlling shrubs.
- Animals activating the carbon pump.
- Animals providing microbiological life to soil.
- Animals fertilizing and seeding.
- Animals respecting the needed recovery time for grasslands and soil fauna.

Results observed

El Baldío implements an exhaustive monitoring system to measure the impact of these interventions in soil health. The monitoring approach covers three main pillars:

- Biodiversity: Soil fauna, pollinators, coprophages and decomposition rates
- Soil functioning: Chemicals (pH, OM, NPK, Ca…), Soil C, Enzymatic activity, microbial biomass, infiltration rate
- Pasture health: Ecological Outcome Verification (EOV), Shrub stratum consumption rate, herbaceous stratum consumption rate.

The effects of rotation grazing have been evaluated in nine plots located on three livestock farms in the southwestern Iberian Peninsula and compared to nine control plots from neighbouring farms under conventional grazing.

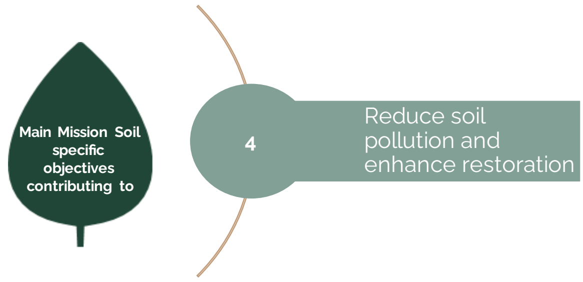
The indicators subjected to analysis included: Ecological Health Index (EHI), plant richness and biodiversity, biological activity of ants, earthworms, and butterflies, and soil quality - including bulk density, total carbon and nitrogen, phosphorus, calcium and potassium availability, microbial diversity, and enzymatic activity.

The results reveal better values in all analysed indicators in the plots with adaptive rotation grazing compared to the control ones, except for butterfly biological activity. Significant differences were found in soil coverage, dung decomposition, species richness, and phosphorus and potassium availability ($p < 0.05$). Although more long-term studies are needed, the results show a tendency towards improved ecosystem functioning in the farms using adaptive rotational grazing.

LH2. Mediterranean Industrial Soil - Mining district of Cartagena - La Union

This chapter presents the general information of LH2; LH representatives, geoclimatic description, socioeconomic description, identified challenges, proposed solution and results observed.

Summary



Coordinator partner	UPCT
LH name (location)	Mining district of Cartagena - La Union
Region	Murcia
Country	Spain
Area (Ha)	6 ha
Soil health challenges	• Soil and water pollution • Hyperacidification • Hypersulfation • Low/null nutrients and organic matter contents • Metallic (Cd, Cu, Pb, Zn) contamination • Non-metallic (As) contamination • Secondary Salinization • Null vegetation cover

Figure 10: Summary of general information, LH2.

LH representative

Universidad Politécnica de Cartagena

UPCT, Universidad Politécnica de Cartagena, is a public university with a long history and tradition in engineering and economic studies. It greatly emphasises international cooperation and mobility, welcoming approximately 200 foreign students and lecturers. With over 90 R&D groups, this University aims to be not only a place for the dissemination of knowledge but also a source of scientific and technological creation. These groups carry out basic and applied research in various scientific fields. UPCT manages 22 European projects in leading programmes, such as Horizon Europe, Horizon 2020, LIFE+, INTERREG and Erasmus+."

Geoclimatic description

The two mine tailings selected for InBestSoil, Santa Antonieta Mine and San Francisco Javier Mine, are located in the former metal mining district of Cartagena-La Union (Murcia Region, Spain). The area presents a Mediterranean semiarid climate with a mean annual precipitation ≈200-300 mm, a mean annual temperature ≈17 ˚C, and a mean annual evapotranspiration rate ≈1000 m.

Figure 12 - Location of Santa Antonieta and San Francisco Javier mines.

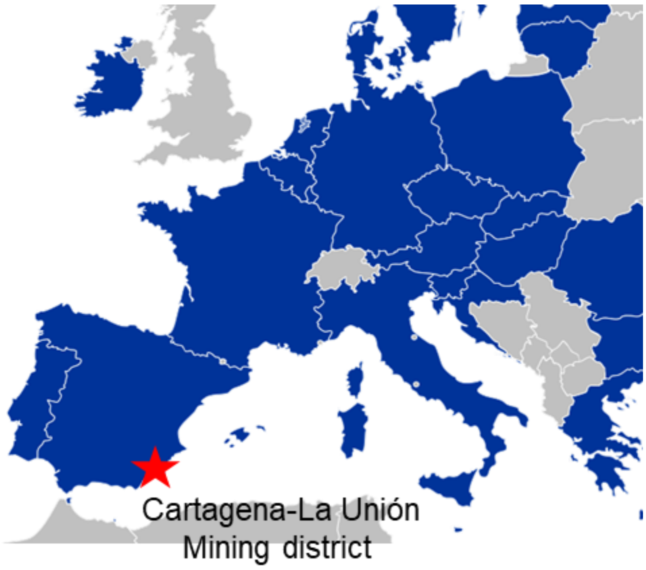


Figure 11 - Location of Cartagena - La Union metal mining district.

Socioeconomic description

La Unión is one of the primary municipalities dedicated to mining exploitation in the Region of Murcia. Table 3[7], presents the number of jobs across various economic sectors within the municipality. As observed, the industrial sector, which includes mining, ranks as the second most important sector of activity in La Unión, with the service sector leading the way with 7,292 employed persons. Furthermore, as depicted in Table 3, the industrial sector exhibits stability over the analysed period with a discernible upward trend, growing from 918 jobs to 970 in the year 2023, representing a 5.66% increase.

These data reflect how the industrial sector and, consequently, mining-related activity are strong economic drivers in the municipality upon which the lighthouse is based.

	2019	2020	2021	2022	2023
Agriculture	393	429	424	439	428
Industry	918	918	928	965	970
Construction	598	623	646	719	731
Services	4,640	4,443	4,746	4,776	5,061
Total	6,549	6,413	6,744	6,906	7,292

Table 3 - Employment (number of people) by Economic Sector in La Unión.

[7] CERM (Centro Regional de Estadística de la Región de Murcia).

Identified challenges

Mine tailings were generated during the intensive mining activities in the 20th century to extract Fe, Pb, and Zn. Mining activities had been under operation for more than 2500 years in Cartagena-La Union mining district until 1991 and have generated high amounts of residual materials accumulated in mine tailings. These are characterised by poor physical structure, strong acidification processes (which confer them high metals solubility), low organic matter and nutrient contents, high salinity, scarce or null vegetation and accumulation of heavy metals (mainly Pb and Zn). These mine tailings are of great concern due to the risk their toxic inorganic elements pose to the environment when they are dispersed. The environmental impact caused by the waste produced by mining and metallurgical activities has resulted in marked negative effects on soil, water resources (surface, groundwater, and marine water), landscape, atmosphere, and biota.

The risk of erosion, by water and wind, is the most important environmental issue due to its implications. Pollution dispersion from the mining area by water and wind erosion also reaches cities, recreative areas and even croplands. The chronic exposure to polluted airborne pollutants from tailings can lead to health risks for the surrounding populations.

Considering the limiting conditions of the soils it was essential to realise a sustainable alternative for the reclamation of mining sites using the strategy of aided phytostabilization.

Figure 13 - Mine waste in the former metallic mine area of La Union-Cartagena.

Figure 14 - Mine tailing in the former metallic mine area of La Union-Cartagena.

Proposed solution

The remediation of the Santa Antonieta mine tailing consisted of the creation of artificial soils (Technosols) applying the aided phytostabilization technique based on the combination of heavy metal-tolerant plants (phytostabilisation) and organic or inorganic amendments (chemical stabilization), which aim to reduce soil metal bioavailability while improving soil health.

The reclamation was carried out using marble waste (calcium carbonate) (figure 15 and 16) and pig slurry/manure as amendment materials in order to reduce the mobility of heavy metals, build-up soil organic matter and improve soil properties to establish plant cover. Marble waste generated from marble industry and pig farms present alkaline and organic characteristics, respectively, to improve physical, chemical, and biological conditions. Marble neutralizes the acidity and immobilizes heavy metals. The application of these materials ensures heavy metals immobilization, the development of microbial communities and plant colonization, essential factors to soil formation and evolution. Moreover, the plant species retain soil avoiding erosion and dispersion of contaminated material. The use of species tolerant to extreme soil conditions and high content in heavy metals (e.g., *Piptaterum miliaceum, Salvia rosmarinus, Pistacia lentiscus, Dittrichia viscosa, Hyparrhenia hirta*) ensure their viability.

Figure 15 - Amendment application in Santa Antonieta mine tailing.

Figure 16 - Inorganic amendment (calcium carbonate).

Figure 17 - Santa Antonieta mine tailing after the reclamation in 2012.

Results observed

Figure 18 - Santa Antonieta mine tailing in 2023.

The main result of this project was the reclamation of the Santa Antonieta mine tailing using Technosols and phytostabilization. The reclamation improved soil physical, chemical, and biological conditions, which guarantee the development of microbial communities and plant colonization, essential to long term soil formation and evolution. This will decrease the risk of erosion, by water and wind. In the whole, we meant to achieve a landscape restoration based on ecological and aesthetic criteria.

During the next 6 months immediately after implementing the reclamation of Santa Antonieta mine tailing, significant improvement was observed in soil health. Specifically, an increase in pH; an increase in soil microbial abundance and activity; a decrease in bioavailable Cd; a decrease in soluble Cd, Pb and Zn; an increase in organic carbon; and an increase in total nitrogen.

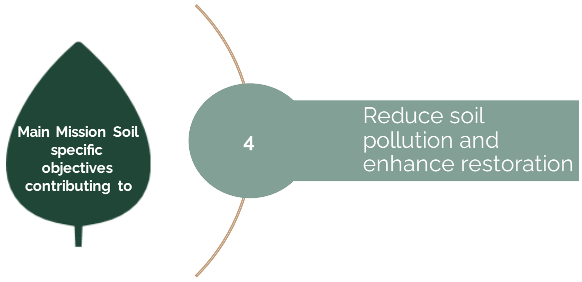
Moreover after 2 years from the remediation, a significant decrease in bioavailable Pb and Zn was observed and an increase in aggregate stability. However, the most remarkable change was the increase in vegetal cover. In 1 year, vegetation cover increased from 0% to 50%. Related to vegetation richness, it was observed an increase from 0 to 4 after 1 year, and to 6-7 after 2 years.

Figure 19 - Santa Antonieta mine tailing in 2023.

LH3. Atlantic Industrial Soil – Old Touro Copper Mine

This chapter presents the general information of LH3; LH representatives, geoclimatic description, socioeconomic description, identified challenges, proposed solution and results observed.

Summary



Coordinator partner	Centro de Valorización Ambiental del Norte S.L. (CEVAN)
LH name (location)	Touro
Region	Galicia
Country	Spain
Area (Ha)	560 ha
Soil health challenges	• Soil and water pollution • Hyperacidification • Hyperoxidation with Fe^{+3} • Hypersulfation • Hyperaluminization • Metallic contamination (Mn, Cu, Zn, Ni) • Extremophile Ecosystems • Bio-catalysis acceleration caused by oxygen-reduction reaction.

Figure 20: Summary of general information, LH3.

LH representative

CVAN, Centro de Valorización Ambiental del Norte S.L., is a technology-based company specialized in the design, development, and manufacture of "tailor-made" Technosols for different environmental and productive applications. CVAN has extensive experience in waste management and environmental solutions that seek to eliminate or mitigate the problems of contamination in soils and waters derived from various industrial, agricultural, or mining activities. This experience allows CVAN to participate in several R&D&I projects with national or international funding.

CVAN actively collaborates with the Environmental Technology Laboratory of the University of Santiago de Compostela for the execution of its R&D activities and has 5 employees and external collaborations with researchers from the USC.

Geoclimatic description

Touro is a Spanish municipality belonging to the province of A Coruña, in the autonomous community of Galicia. Touro is located south of the province of A Coruña, bordering the river Ulla, which separates it from the municipality of Villa de Cruces (Pontevedra). To the north it borders with the municipality of El Pino; to the east, with Arzúa, and to the west, with Boqueixón.

Touro's climate is clearly defined by the oceanic influence, where temperatures are mild, with an average annual temperature of 12.6ºC, an average minimum temperature of 7.9ºC and an average maximum temperature of 17.2ºC. As for the rainfall regime, the municipality is characterized by abundant rainfall (average annual rainfall = 1.886 mm), distributed mainly in autumn, winter, and early spring.

Figure 21. Geographic location of LH3.

The Touro mine is in a formation of Precambrian granitic amphibolites mineralized with metallic sulphides, pyrite and pyrrhotite, with significant levels of chalcopyrite and minor amounts of blende and other metallic sulphides. The minerals present in the superficial cover of the deposit are Ferrihydrite, Goethite, Jarosite and Schwermanite (among others), which are accompanied in the summer by different secondary sulphates of Iron, Magnesium, etc. Its origin is like that of the so-called "Faja Pirítica Andaluza", volcanic sedimentary in the oceanic crust bottoms. But, unlike this one, the content of As, Cd, Hg, Se, Pb and Zn is much lower. The amphibolitic material corresponds to oceanic crust, having dated zircons in similar rocks from Galicia from 900 and 1100 million years ago. On these materials, there is a formation of schistose rocks attributed to the Precambrian-Paleozoic transition.

Socioeconomic description

Touro is a relatively small municipality with a population of 3.500 people. Most of its socioeconomic characteristics resemble the situation in other rural municipalities, with a progressive loss of population and a relatively high percentage of the population over 64 years old (35%, while in the region is 25%) (table 4).

EMPLOYMENT BY SECTOR	% of employment
Primary sector (agriculture)	15%
Industry	19%
Construction	10%
Tertiary sector (services)	56%

Table 4. Employment percentage per sector LH3 area (Touro, Galicia, Spain).

Traditionally, the agricultural and livestock sector was Touro's mainstay of the economy. Nowadays few young people are incorporated directly in this sector, although small parishes with a low density of livestock farms still exist. It is worth mentioning the persistence of the vegetable gardens, as suppliers of food for Galician households but not used to generate wealth directly, the slaughter of pigs and the breeding of chickens, sheep, and rabbits. The opening of an industrial park in the municipality in 2018 also served as a stimulus for its economy and the production of employment in this sector, which today employs almost 20% of all workers living in Touro.

Another important sector was mining. The Rio Tinto mining operations, now closed, provided employment for a short period of time (1974-1986) where more lasting economic activities were not developed. The owners of *Explotaciones Gallegas* have an agreement to try to resume production at the mine with the multinational Atalaya Mining. The first request to the Xunta to reopen the Touro mine was rejected. The company has exhausted the administrative route with several appeals and sued the Xunta in court. The matter is being reviewed by the Superior Court of Justice of Galicia. In any case, the mining alliance has announced that it will present another project for the mine.

Identified challenges

The mine of Touro is located 20 km NE of Santiago de Compostela. It is an ore deposit of metallic sulphides, with an area of 600 ha, that has been exploited by the company Río Tinto Patiño for fourteen years (1974-1988) to extract copper. This activity led to a profound degradation of the environment with deep cuts, vertical walls, sterile dumps, and a large mine tailings pond. The materials left on the surface, lacking vegetation and soil cover, undergo a rapid oxidation of the sulphides generating a hyper-acidic mine drainage which contaminates the rivers of the Ulla basin.

Since the early years of operation, processes of sulphide oxidation were identified, probably due to the rapid oxidative kinetics of pyrrhotite. Excavation and extraction pits, waste rock dumps, and a flotation sludge waste pond, with the latter being the main source of hyperacid waters. The mine soils exhibited hyperacid reactions under forced oxidation conditions, with minimal nutrients and the absence of any biotic activity except for extremophiles. Seeds did not germinate, and any plant that managed to establish itself was quickly eliminated. From the end of mining operations until the start of rehabilitation activities in 1989, the food chain was completely eradicated in the mine soils, and the aquatic fauna of vertebrates and aquatic insects in the surrounding streams were entirely eliminated.

Proposed solution

To accelerate the rehabilitation processes, the kinetics of the main types of soil reactions were analysed, and the fastest ones were selected (ionic associations, ion exchange, and adsorption) to design interventions aiming to neutralize them.

Figure 22. 2004. Before technosols intervention (LH3): pH 2,6-2,8; only extremophile organisms.

Figure 23. 2018. After technosols intervention (LH3): pH 6,5-7,5; entire trophic chain, productivity, and CO2 fixation.

Rehabilitation activities began in 1989, starting with the incorporation of liming residues (mussel shells and biomass combustion ash) and the planting of pine and eucalyptus trials. The rate of plant elimination was reduced to a small percentage. After studying the Eh-pH conditions and geochemical conditions of the soils, the idea of rehabilitating with technosols. was raised. These were artificial soils made from mixtures of inorganic and organic residues, considering that soils with the appropriate composition and properties could be designed to mitigate the impacts by applying knowledge from Soil Science and Biogeochemistry. The selected materials for the elaboration of technosols included organic reducers to decrease the kinetics of sulphide oxidation, liming agents to neutralize excess acidity, sulphate adsorbents to reduce the mobility of the main mobilizing anion, and nutrients to restore biological activity.

For the design of the soils, natural or anthropogenic soils were used as models (Terra preta and Historical Maori soils). The first soils used as a model were sambaqui soils, elaborated by the Guarani indigenous people inhabiting the mangrove areas of the coast of Sao Paulo (Brazil). These soils have formed in the mangroves of the Cananeia area due to the abandonment of oyster shells used for food, which mix with biomass remnants, ashes, and charcoals from cooking fires. In the production of technosols, the oyster shells were replaced with mussel shells (biogenic $CaCO_3$). The second model used was Andosols, chosen for their ability to adsorb anions and heavy metals and their buffering capacity (Andic technosols). Later, nutrient rich eutrophic technosols were added to enhance fertility and biotic activity, imitating the qualities of Amazonian Terra Preta soils (Practic technosols).[8]

The whole mine has been treated with technosols, except for 5 ha area that has been left untreated as a control area. In the dumps, the Andic technosols, with a high content of labile organic matter, diverse tree plantations were developed: eucalyptus, pines and deciduous, while in the cuttings regular vegetation is also growing. Activities to restore the mine are still ongoing nowadays by the company *Tratamientos Ecológicos Gallegos*, that produces the technosols in their premises located in the mine land.[9]

For the recovery of the quality of hyperacid waters, the construction of a "reactive wetland" began in 2002. A reactive wetland is an artificial wetland with multiple technosols to accelerate biogeochemical reactions:

- Impermeable eutrophic technosol,
- Reducing technosol, neutralizing technosol,
- Sulphate adsorbent technosol,
- Eutrophic technosol.

The goal was to lower the Eh from > 600 mV to < 300, to reduce sulphates to sulphides and raise the pH, causing the precipitation of aluminium and heavy metals. The development of Typha latifolia was encouraged inside the wetland to contribute biodegradable organic matter and maintain at least sub-oxic conditions. A vegetative cover with Salix atrocinerea was established at the edges. Starting from 2008, the system became self-sustaining, without new material inputs. A 6-hectare reactive wetland treated leachates from approximately 200 hectares of waste rock dumps and hyper acidic pits.

On the platform of an amphibolite pit, the construction of a reactive wetland began, closing an area with low-permeability eutrophic technosols to collect and contain the hyperacid waters from the elevated waste rock dumps, maintaining an average residence time of 2 months.

[8] Macías García, F., García, I.M., Macías Vázquez, F. (2023). Environmental and Productive Applications of Tailor-Made Technosols: Biosphere Learnings. In: Chaminé, H.I., Fernandes, J.A. (eds) Advances in Geoengineering, Geotechnologies, and Geoenvironment for Earth Systems and Sustainable Georesources Management. Advances in Science, Technology & Innovation. Springer, Cham. https://doi.org/10.1007/978-3-031-25986-9_36

[9] Macías-García, F. y otros, 2009. Recuperación de aguas ácidas de la mina de Touro mediante sistemas integrados de barreras reactivas con diferentes Tecnosoles y humedales. Minería Sostenible. Cámara Oficial Mineira de Glicia. A Coruña., pp. 963-973

Results observed

In the reactive wetland, aquatic insects started to develop as early as 2004, starting with water striders followed by backswimmers and aquatic beetles. Later, carnivorous aquatic insect larvae (odonates) emerged, and by 2008, mayflies appeared, indicating an improvement in water quality sufficient for drinking water purposes and direct discharge into the river. The insects supported the feeding of numerous passerine birds and two species of frogs and toads, while these amphibians allowed the development of colonies of coots, snipes, herons, and other waterbirds. Finally, the food chain was completed with the appearance of raptors such as hawks, harriers, and black kites. By 2008, the pH reached values close to 7.0, sulphate levels decreased to below 2000 mg/l, and the concentration of dissolved aluminium dropped to values below 0.1 mg/l (1000 times less than the concentration of leachates entering the reactive wetland from the waste rock dumps).

Figure 24. Evolution of technosols interventions overtime in LH3.

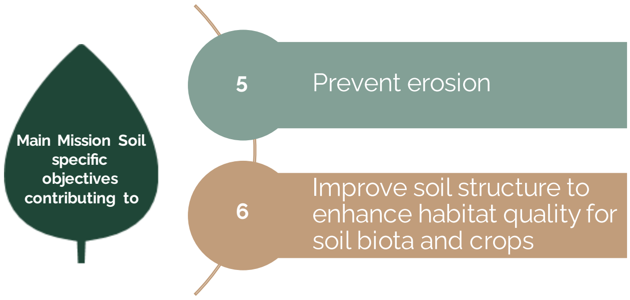
In the dump rehabilitated with eutrophic andic technosols, made to imitate soils with andic properties retains sulphate ions and meta-stabilises large amounts of organic matter (C > 12%) in the surface horizons, has become an excellent sink of carbon, and is quite resistant to mineralisation. Twenty-three years later, the pines planted are timber-yielding and spontaneous autochthonous herbaceous and shrubby plants have grown in their undergrowth. An abundant fauna has developed in the food chain, with rabbits, hares genets, wild boar and fox, and a multitude of passerines and raptors such as the black kite.[10]

[10] Macías-García, F., Camps Arbestain, M. & Macías, F., 2009. Utilización de Tecnosoles derivados de residuos en procesos de restauración de la mina de Touro.. Minería Sostenible. Cámara Oficial Mineira de Galicia. A Coruña, pp. 651-661.

LH4. Continental Urban Soil – Peri-urban soils, Zagreb

This chapter presents the general information of LH4, LH representatives, geoclimatic description, socioeconomic description, identified challenges, proposed solution and results observed.

Summary



Coordinator partner	University of Zagreb, Faculty of Agriculture
LH name (location)	Peri-urban soils Zagreb
Region	Zagreb
Country	Croatia
Area (ha)	1 ha
Soil health challenges	• Overexploitation • Low biodiversity • Structural deterioration • Low soil quality • Soil compaction • Low soil organic matter content • Soil abandonment • Flood risk

Figure 25: Summary of general information, LH4.

LH representative

The Faculty of Agriculture, University of Zagreb (UniZG) is dedicated to the education of highly qualified experts, development and broadening of professional knowledge in the field of agriculture and related sciences. Applying the highest academic standards, we enable students to acquire competences based on the newest scientific knowledge, for the benefit of society.

The Vision of the Faculty of Agriculture is to strategically position itself in Croatian higher education and research areas, as well as an internationally recognised and acclaimed research and teaching institution.

Geoclimatic description

Zagreb, with its diverse array of land use and types, experiences significant impacts on soil, the environment, and soil ecosystem services due to land use changes. The selection of the City of Zagreb was motivated by the substantial presence of native forests and agricultural land within its boundaries, making it an attractive place to live. However, over the past few decades, deforestation and cultivation have rapidly increased in these areas, without monitoring the resulting changes in the soil system and environment.

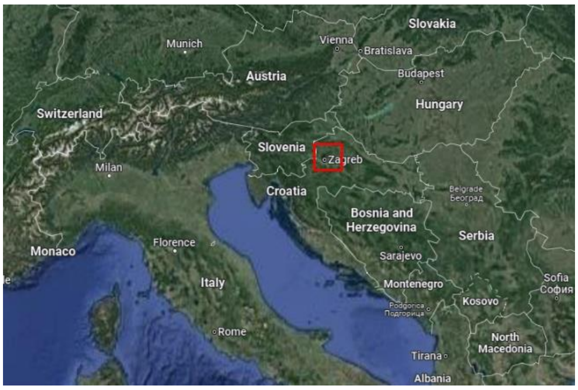


Figure 26. Geographic location of LH4.

The LH4 site, situated in Šašinovečki Lug, near Sesvete, is approximately 15 km away from the UniZG campus and encompasses 76.2 hectares of agricultural lands.

The four land use types in the Zagreb Lighthouse include:

- Quercus petraea and Robinia pseudo acacia Forest (>200 years).
- Apple Orchard (since 2007).
- Abandoned agricultural land -Secondary Forest (afforested) (since 1991).
- Grassland (since 1996).

Figure 27. Overview of LH4 monitored land.

The dominant soil type in the region is Stagnosols, characterized by a silty clay loam texture. These soils have developed on Pleistocene loam and Pliocene clay substrata.

Socioeconomic description

Croatia's economy is largely dependent on the service sector, which comprises about 70% of the total GDP. Zagreb, specifically, is its economic center, generating 31.4% of the country's GDP; important industries in Zagreb are chemical, pharmaceutical, textile, food and drink processing, and manufacturing of electrical machines and devices.

Zagreb is also an important business centre, a transport hub, and an international trade centre, considered the junction of trade between Central and East Europe. The largest industry in Zagreb is wholesale and retail commerce and motor vehicle and motorcycle repair, accounting for 38.8% of the city's revenue, followed by manufacturing, at 20.6%. Most of Croatia's industrial and service sector is clustered in Zagreb. Other notable industries include information and communication, and electricity and gas supply. Professional, scientific, and technical activities account for just 5% of the city's revenue.

The Lighthouse area has three main economic activities relying on two of the land use types mentioned in the previous section:

- Apple production (Apple Orchard).
- Wood stock (Quercus petraea - Robinia pseudoacacia Forest).

Identified challenges

In Zagreb, 2/3 of the land is in agricultural and forest land**,** and at least half is used for agriculture. The increasing global demand for natural goods accelerates the conversion of native vegetation into agricultural lands, and this also affects peri-urban and urban soils.

As of today, there are almost no-good practices detected in land use and agricultural practices in Zagreb. So far, all agricultural practices have been carried out with the same methods used for decades, following the practices learned from those who worked the land before them. Because of this, the use of pesticides and mineral fertilizers is still widespread, there is very poor crop rotation or there is no crop rotation at all, no cover cropping, no intermediate cropping etc. In addition, soil health has not been monitored, so no related measures have been taken.

It is also necessary to consider the type of soil in Zagreb, which is dominantly Stagnosols, with silty clay loam texture, developed on Pleistocene loam and Pliocene clay substrata.

Having this type of soil means that there are certain types of problems associated with it, something that has not been considered so far for agricultural practices. The challenges identified for the Lighthouse land uses are as follows:

- Soil is very susceptible to compaction.
- Soil is susceptible to erosion.
- Has poor structural stability.

Proposed solution

The lighthouse was created given the clear need to monitor both soil health and to develop new agricultural practices in Zagreb, especially considering the amount of soil used for agriculture. This is extremely important from the view of spatial planning since land use generates the ability of soils to increase carbon sequestration or mitigate floods.

The selected soil management practices to address the issues described above were based on promoting appropriate and sustainable natural soil practices for each of the land uses:

Quercus petraea and Robinia pseudo acacia Forest

- No soil disturbance
- No mineral fertilisation
- Natural decay of trees and leaves

Apple Orchard

- Mulching

- Low soil disturbance
- Permanent grass cover
- Appropriate fertilisation

ABANDONED AGRICULTURAL LAND -SECONDARY FOREST (AFFORESTED)

- No soil disturbance

GRASSLAND

- Mulching
- No soil disturbance
- Permanent vegetation cover

Results observed

To gather data on the soil characteristics, soil sampling is conducted at a depth of 0-10 cm with 8 replicates per land use type, due to Zagreb temperate continental climate, with an average annual precipitation of 852 mm and a mean annual temperature of 10.3 ˚C.

This sampling is repeated once per season as part of the monitoring strategy. The properties being measured include:

- Bulk density.
- Water holding capacity.
- Soil aggregate stability.
- Mean weight diameter of aggregates, penetration resistance.
- Soil carbon concentration (and stocks).
- CO_2 emissions (fluxes).
- Infiltration.

These parameters provide valuable insights into the physical and chemical attributes of the soil, as well as its capacity to retain water, maintain stable soil aggregates, resist penetration, store carbon, and facilitate CO_2 emissions and infiltration.

Preliminary results showed higher soil water content in grassland than in other land uses. A nearby Cropland land use control area had significantly higher compaction than other land uses, whereas forest land use had lower compaction. Higher compaction was noted during the summer than during other seasons.

The mean weight diameter has the next decreasing trend: orchard > grassland = abandoned agricultural > forest. The mean weight diameter was higher during the winter due to freezing and thawing processes than in other seasons.

Forest land uses showed higher water stable aggregates values. Grassland and forest land uses obtained a higher infiltration than abandoned agricultural and orchard land use.

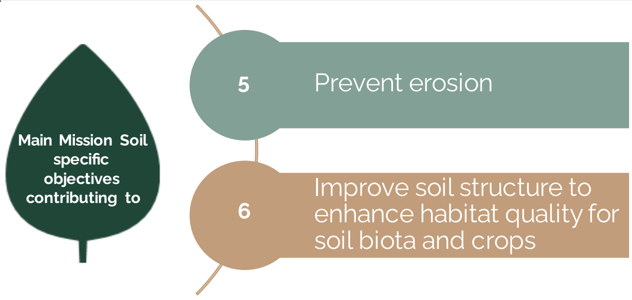
Soil CO_2 emissions registered higher values during autumn and spring than in winter, and the results show higher CO_2 values in LH4 land uses than in nearby control areas with poor land management approaches.

Finally, CO_2 emissions were higher in grassland than in other land uses. Preliminary results indicate that land uses with intensive agricultural practices decline soil quality and flood retention capacity in peri-urban areas.

LH5. Boreal Urban Soil – Baltupiai urban gardens

This chapter presents the general information of LH5; LH representatives, geoclimatic description, socioeconomic description, identified challenges, proposed solution and results observed.

Summary



Coordinator partner	Mykolas Romeris University Laboratories (MRU LAB)
LH name (location)	Baltupiai
Region	Vilnius
Country	Lithuania
Area (Ha)	7352ha
Soil health challenges	• Poor land use (use of agrochemicals) • Erosion • Flooding regulation

Figure 28: Summary of general information, LH5.

LH representative

Mykolo Romerio universitetas

The Mykolas Romeris University Laboratories (MRU LAB) is composed of interdisciplinary teams of scientists, researchers, students and other interested individual groups, who implement MRU research programs, develop an ecosystem based on a high-level of knowledge, state-of-the-art technology, collaboration between science, business, and government institutions and society, and network governance.

The MRU LAB is open not only to MRU, but also to scientists, researchers, students from other institutions and business, government institutions, non-governmental organisations partners, with whom innovative solutions to the most important challenges of modern society are sought.

Geoclimatic description

The average annual temperature in Vilnius is +8.1 ˚C (2016 to 2020). The coldest month is January (−3.5 ˚C), and the warmest is July (+17.8 ˚C) (1971–2000). Vilnius has a population of 588,412 (January 1, 2021) and an area of 401 km2. Since 1984, the city's historical centre has been acknowledged as a UNESCO World Heritage Site. According to the Vilnius master plan (Vilnius municipality, 2022), green zones cover an area of 73.52 km2 or 18.4 % of the municipal territory.

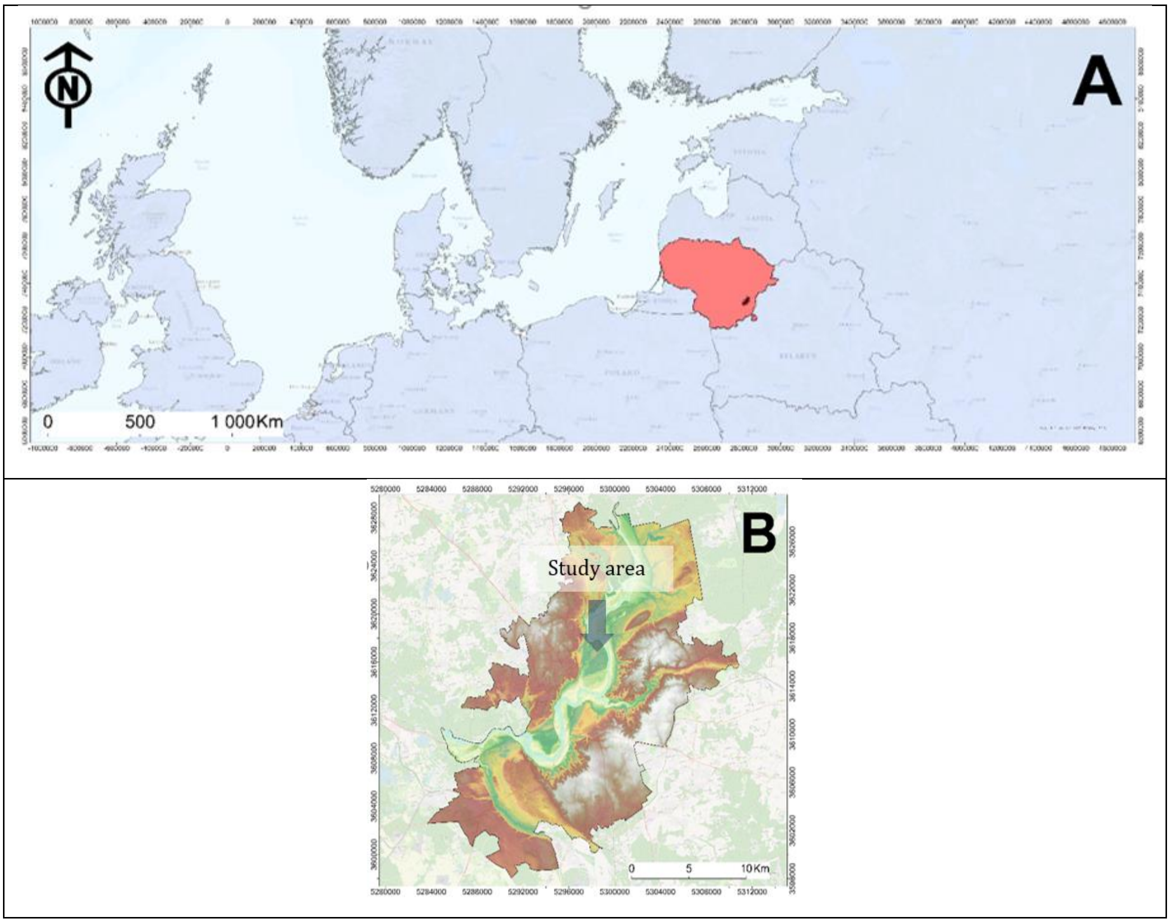


Figure 29. Vilnius Elderships distribution and specific location of LH5.

Socioeconomic description

Vilnius is the major economic centre of Lithuania. The GDP per capita in Vilnius metropolitan area (Vilnius County) is almost 30.000€, making it the wealthiest city in Lithuania and the second-wealthiest city in the Baltic states after Tallinn. The most important sectors of Lithuania's economy in 2020 were wholesale and retail trade, transport, accommodation, and food services (29.9%), industry (20.5%) and public administration, defence, education, human health and social work activities (16.1%).

Community of urban gardeners of Baltupiai. Old neighbourhoods inside Vilnius, are mainly composed by individual houses surrounded by gardens. Most of the gardens in Baltupiai were established in late 1950s. The gardens are mainly used for personal and family purposes. Approximately from 2010 many gardeners have stopped planting fruits and vegetables and arranged lawns. The gardeners are not associated in a formal association.

In the LH6, there are 4 different land uses that have selected for their comparation (figure 30): garden, grassland, park and lawn.

Identified challenges.

Community of urban gardeners of Baltupiai. Old neighbourhood in inside Vilnius mainly composed by individual houses surrounded by gardens.

The main issues identified with soil in Baltupiai are the following:

- Poor land use: One of the biggest problems associated to soil use in Baltupiai is that most gardeners still use agrochemicals on the management of the land, as well as the intensive production between April and September. Gardeners what to produce as much as possible in these months since wintertime is very harsh.
- Flooding regulation: in the last year, several parks are being flooded.
- Erosion.

Proposed solution

Considering the specific difficulties encountered with the gardens in Baltupiai, LH5 assessed the following ecosystem services to understand the impact of different practices on them:

- Flood regulation
- Erosion regulation
- Food production
- Carbon sequestration
- Recreation

In addition to the sample collection, LH5 will carry out the following activities:

- Survey of farmers for ES assessment (cultural).
- Engagement of different stakeholders: municipality, NGO's, farmers, Ministry of the environment and agriculture.
- Proximal Sensing (UAV) analysis to assess ecosystem services.

Results observed

Translating this information in ecosystems services assessment, the lawn has a lower capacity for flood regulation, carbon sequestration and erosion regulation than the other land uses. Urban park was the land use with the highest capacity for flood regulation, and urban gardens had the highest values of carbon sequestration.

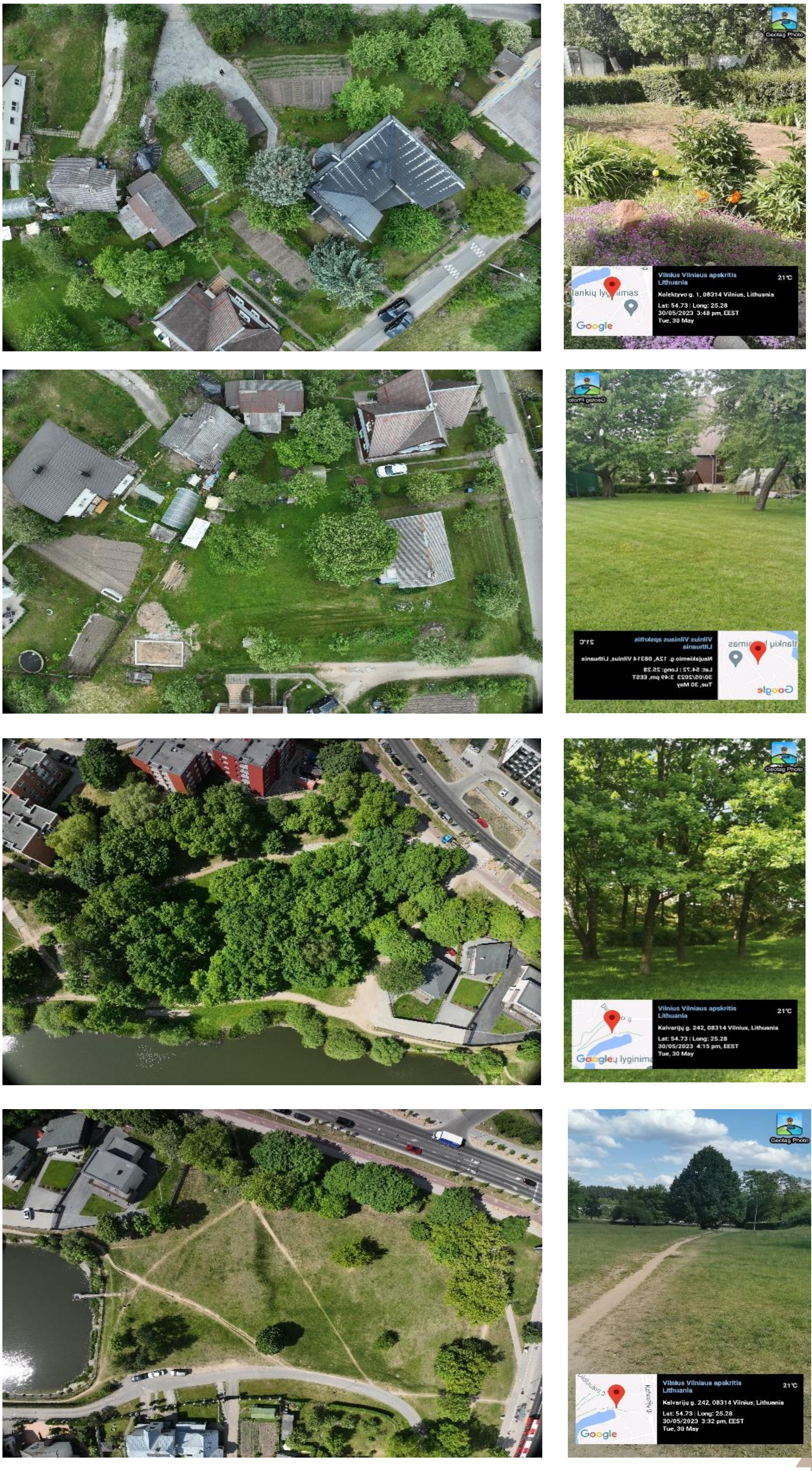
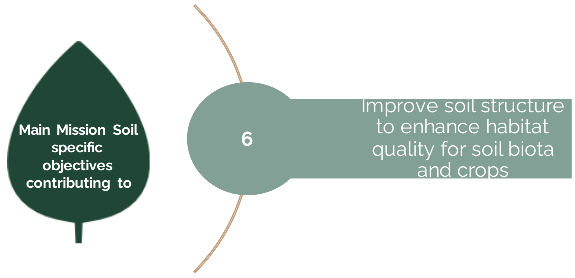


Figure 30: There are four different land uses in the LH5 (in order: garden, grassland, park, and lawn).

LH6. Boreal Forestry Soil – Mežole, Latvia

This chapter presents the general information of LH6; LH representatives, geoclimatic description, socioeconomic description, identified challenges, proposed solution and results observed.

Summary



Coordinator partner	Latvian State Forest Research Institute "Silava", The Forest Research Station
LH name (location)	Mežole
Region	Vidzeme
Country	Latvia
Area (Ha)	9 959.5 ha
Soil health challenges	• Diverse soil organic matter content • Unbalanced soil nutrient content • Soil acidification • Soil erosion on slopes

Figure 31: Summary of general information, LH6.

LH representatives

SILAVA **Latvian State Forest Research Institute "Silava"** (LSFRI Silava) founded in 1946, is the main centre of forest science in Latvia and leader of scientific ideas in forestry and related research and development in the country. The institute's research areas include forest ecology and silviculture, forest tree breeding and climate change, forest genetic resources, forest regeneration and establishment, forest phytopathology and mycology, forest entomology, forest operations and bioenergy, wildlife management and forest products processing. The organisation counts with 44 researchers with a doctoral degree in forestry, biology or other sciences.

MEŽA PĒTĪŠANAS STACIJA **Station Latvia** is a public agency founded by LSFRI Silava and Latvia University of Life sciences and Technologies. Its purpose is to manage the scientific research forests, to ensure the continuity of research for long-term research sites, to equip and monitor environmental and forest objects. In 2001 Council of Ministers of the Republic of Latvia assigned 28 000 hectares of state-owned forest to long- term research purposes within forestry sector. Today, 12.5% of this total area is covered by long-term research objects.

Geoclimatic description

In Latvia, the average annual air temperature is +5.9˚C. The year's warmest month is July, its average temperature is +17.0˚C and average maximum temperature +21.5˚C. The coldest months are January and February, when the average temperatures are -4.6 and -4.7˚C, and average minimums -7.5 and -7.9˚C. So far, the highest observed temperature in Latvia is +36.4˚C, the lowest: -43.2˚C.

The average annual precipitation in Latvia is 667 mm. The months with most precipitation are July and August, in each of which average rainfall is 78 mm. The least precipitation is in February and March – each of which has on average 33 mm. Annual average relative humidity is 81%. The sun shines on average 1790 hours a year, which is about half of the possible sunshine duration (when the sky is clear).

Throughout the year, the generally prevailing winds are from the south, southwest and west. The highest wind speeds are in November, December and January (monthly averages of 3.9 to 4.0 m/s). The lowest wind speeds are in July and August (monthly averages of 2.8 m/s). The highest wind speed (10-minute average wind speed value) observed so far is 30 m/s, the strongest gusts are 48 m/s.

LH6 is located in scientific research forests of Mežole forest region in the central part of Vidzeme region, northeast of Latvia. Vidzeme is the largest region in the country, covering 15 245 km² or 24% of its territory. The largest part of the region (currently 56%) is occupied by forests, which has been increasing in recent years. Agricultural land accounts for about 34% of the territory. The region is characterized by low built-up density and a high proportion of natural landscapes with low human influence. Two rivers - Rauza and Sepka - flow through the area. Forest ecosystems are representative for Latvia, the main tree species are Scots pine (19.8%), Norway spruce (46.8%), birch (22.7%), black alder (5.7%) and aspen (3.9%). Areas with forest management restrictions for nature conservation purposes take up 37.1% of Mežole forest region. In the nature reserve "Mežole" (Natura 2000 area), EU habitats 91D0, 7110, 7140, 9010, 9080, 7160 are present.

Socioeconomic description

Population in Vidzeme region was 180 766 or 9.7% of the total population in Latvia in 2022. Gross domestic product (GDP) of Vidzeme region was 6.7% (table 5) of the total GDP in Latvia in 2020, constituting 2 041 935 thousand euro or 11 068 euro per capita. The primary sectors (agriculture, forestry, fisheries) are 14.4% of the Vidzeme region's economic structure. The most economically active units (the largest number of enterprises) in the region are forestry, woodworking, agriculture, and animal husbandry. According to the Central Statistical Bureau of Latvia (CSB) the employment rate in the region in 2022 in the 15-74 age group was 62.3%, while the unemployment rate was 6.0%. The employment rate in the 15-64 age group was 70.2%, while the unemployment rate was 6.3%. The average salary in Latvia after taxes in 2022 was 1006 EUR while in the Vidzeme region it was 810 EUR per month.[11] [12]

Value added at current prices by economic activities (in 2020) in Vidzeme region (Latvia) [13]	Vidzeme region	
	Thousand euro	Share from total in Latvia, %
Total	**1781927**	**6.7**
Agriculture, forestry, and fishing	255651	19.5
Industry	416533	9.8
Construction	107919	6.4
Wholesale and retail trade, repair of motor vehicles and motorcycles, transportation and storage, accommodation and food service activities, information, and communication	324319	4.3
Financial and insurance activities, real estate activities, professional, scientific, and technical activities, administrative and support service activities	272826	4.5
Public administration and defence, compulsory social security, education, human health and social work activities, arts, entertainment and recreation, other service activities, activities of households as employers	404679	7.4

Table 5. Economic added value by sector in LH6 area (Mežole, Vidzeme, Latvia).

Identified challenges

Forest management in boreal/hemi-boreal regions often faces several challenges related to soil quality. Firstly, the threat to soil quality is related to the nutrient losses with surface runoff and soil acidification which alters and may cause a disbalance in the availability of nutrients for subsequent tree rotations. In addition, soil nutrient output with harvested tree biomass in nutrient-poor forest site types is remarkable. Secondly, unsuitable soil preparation methods on slopes may enhance wind and water erosion and the movement of organic matter towards lowland parts. Thirdly, the area contains a former gravel mining site with degraded poor sandy soil, that is necessarily subject to recultivation.

Proposed solution

To prevent insufficient supply of nutrients due to forest harvesting and, thus, repeated removal of nutrients with tree biomass, forest fertilization experiments using wood ash and nitrogen (N) containing mineral fertilizers were initiated in 2016/2017 in spruce, pine and birch stands. Impacts of soil fertilization on groundwater quality and tree radial increment are regularly monitored. In recent years, the area has been affected by events caused by climate change - birch stand was damaged by wind (blown down), while spruce stand was destroyed by bark beetle.

[11] https://stat.gov.lv/en/statistics-themes/environment/nature-resources/tables/drt011-total-and-land-area-regions-cities

[12] https://data.stat.gov.lv/pxweb/en/OSP_PUB/START__EMP__NBB__NBA/NBA031
https://data.stat.gov.lv/pxweb/en/OSP_PUB/START__EMP__DS__DSV/DSV041/

[13] https://stat.gov.lv/en/statistics-themes/economy/national-accounts/2352-gross-domestic-product-regions

Figure 32. Soil fertilization testing in LH6.

To evaluate soil preparation approaches aimed at reduction of soil erosion and GHG emissions, tests of diverse soil preparation methods on slopes and lowland parts (disk trenching and mounding) were initiated in 2020. In sites with wet organic soils, **soil-to-atmosphere GHG fluxes are being regularly monitored**.

Figure 33. Diverse approaches of soil preparation methods in LH6.

LH6 includes former gravel mining area recultivated by natural and anthropogenically promoted afforestation (Nelder Wheel design, different surface terrain and slopes, different tree density and tree species - Scots pine, Norway spruce, Silver birch, black alder). It will increase soil organic matter and nutrient content in soil, improve biodiversity and preserve already spontaneously established recreation opportunities (off-road motorcycling). In addition, buffer strip of deciduous trees was established and soil quality improvement studies are planned.

Figure 34. Former gravel mining area recultivated by natural and anthropogenically promoted afforestation (Nelder Wheel design) in LH6.

Results observed

The results observed in the LH6 include the following aspects of soil quality improvement. Return of nutrients via fertilization, enhanced radial growth of main stand, high increments of the second storey and the undergrowth. However, well-maintained stands are also vulnerable to climate change risks, for instance, wind damage.


Figure 35. Improved nutrient availability and tree density in LH6.

Improved quality of planting sites for trees of the young stand, balanced GHG emissions and water availability, decrease concurrence with other plants.


Figure 36. Improved quality of planting sites and balanced GHG emissions in LH6.

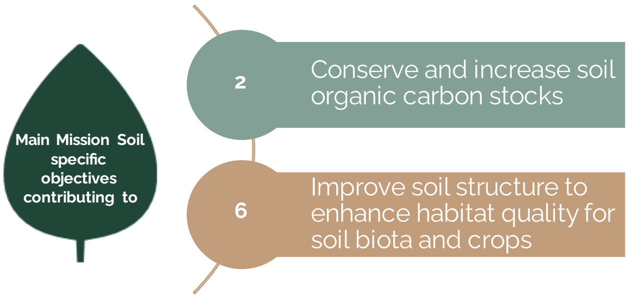
Recultivation of degraded area, restoration of productive functions of forest ecosystem, enhancement of above-ground and below-ground biodiversity of flora and fauna, preservation of spontaneously emerged recreation function.

Figure 37. Restoration of forest productive functions through recultivation in LH6.

LH7. Atlantic Agricultural Soil – Betuwe, the Netherlands

This chapter presents the general information of LH7; LH representatives, geoclimatic description, socioeconomic description, identified challenges, proposed solution and results observed.

Summary



Coordinator partner	Ekoboerderij de Lingehof (EKO)
LH name (location)	Implementation of regenerative practices for soil health and the protein transition in the Netherlands.
Region	Betuwe
Country	Netherlands
Area (Ha)	130 ha
Soil health challenges	• Water management • Compaction • Soil and water pollution • High costs of implementing soil fertility practices

Figure 38: Summary of general information, LH7.

LH representative

Ekoboerderij de Lingehof (EKO) is an organic and biodynamic arable farm which grows more than 10 different crops including vegetables, cereals and legumes. EKO combines the care for soil fertility with the use of technology and precision agriculture for balanced plant growth and efficient business operations.

The farm is keen to try new approaches or giving others the space for entrepreneurship. EKO pioneers with the cultivation of new crops (e.g. quinoa, and white lupine) with modern mechanisation (e.g. camera driven weeding, specialized intercropping machines) and teaming with the soil ecosystem for better soil health (compost extract, plant-based fertilisation, fermentation).

Geoclimatic description

Ekoboerderij de Lingehof is in the Betuwe region (Batavia), a historical and geographical area in the Netherlands known for its distinctive river landscape. This region is nestled in the lowlands of central Netherlands and is shaped by several rivers, including the Waal, the Lower Rhine, the Lek, the Linge, the Korne, and the Zoel.

The Betuwe landscape predominantly features a mix of old stream channels and the stream ridges flanking them, interspersed with basins of river clay set further from the rivers. These ancient river courses are still visible in various parts of the Betuwe landscape, both within and beyond the dykes. Additionally, river beaches, crevasse channels, embankments, and gullies are other typical landforms found relatively commonly in the region.

Ekoboerderij de Lingehof is situated on fertile river clay soil, which is characteristic of the Betuwe region. This soil type is noted for its heavy texture and high fertility, making it particularly well-suited for growing horticultural crops, as well as supporting orchards and tree nurseries. The stream ridges, which contain sandy material on the surface, have traditionally been utilized for horticulture and are regarded as some of the best agricultural lands in the Netherlands. Although river clay is beneficial due to its high water-holding capacity, it poses significant challenges for farming. It is prone to compaction when wet and becomes very difficult to work with when dry, which complicates the use of agricultural machinery.

Socioeconomic description

The upcoming table presents data pertaining to economic activity in the Netherlands[14] for the year 2021:

ECONOMIC ACTIVITY	Region GDP %
Agriculture, farming, fishing	2%
Industry	12%
Services	78%
Other	8%

Table 6. The Netherlands GDP data by sector in 2021. Source: CBS 2021.

The Betuwe is best known for its large-scale horticulture, including the fruit cultivation of crops from the rose family; Especially apples, pears, cherries, plums and strawberries are grown.

The largest cooperative fruit auction in the Netherlands, FruitMasters, is in Geldermalsen (West Betuwe). To a lesser extent, vineyards also occur in the Betuwe, including the Betuws wine estate, which is one of the largest and most famous vineyards in the Netherlands.

In addition to fruit cultivation in orchards, there are also other branches of horticulture in the region that are relatively common, including greenhouse horticulture (especially in the Over-Betuwe) and tree cultivation.

Pilot whales were also relatively common along the banks of the Betuws; these are still present especially in the Tielerwaard. From the willows harvested from the pilot whales, a specific type of Betuwse basket was traditionally braided, which is called a fowl oak. Fowls are used when harvesting the cherries in June and/or July.

The current main economic activity of the LH develops around biodynamic and regenerative agriculture with a specific focus on crop sales, innovation projects, education activities and specialised hired labour. The main crops harvested are currently onion, pumpkin, potato, grass-clover, lupin, peas, sugar-maize, wheat, and rye.

[14] CBS - Statistics Netherlands 2021 - CBS - Statistics Netherlands

Identified challenges

The main issues that EKO wants to solve in the future are the following:

- Difficulties in introducing/ keeping N-fixing crops within the crop rotation due to the absence of value chains that support farmers in getting a good price for their product.
- Reduced availability of good quality organic manure.
- Water related issues. Disruption of soil structure due to compaction when the soil is wet. Increased incidence of draught events resulting in the need to irrigate more often.
- Biodiversity loss due to the use of chemicals in agriculture.

Proposed solution

In the past years EKO has been experimenting and innovating with the following practices:

- Organic (biodynamic) farming.
- Wide crop rotation (8-13 crops).
- Inclusion of N-fixers in the crop rotation.
- Reduced tillage.
- Diversified green manures.
- Precision agriculture.
- Diverse green manures mixes

LH7 aims to keep innovating further in the direction of regenerative farming, working on soil biology to increase plant health and reduce inputs. Practices that are currently being tested are the following:

- Minimize the time in which the soil is bare, for instance by under-sawing crops with a companion mix that stays on the field after the harvest of the main crops.
- Alternative fertilization by utilizing plant ferments, compost tea and bokashi to increase the crop capacity to access nutrients, therefore increasing nutrient use efficiency. The principle behind this is that by creating a balanced soil ecosystem the plant has a wide variety of symbiotic micro-organisms that can support it with accessing the needed resources.
- (Further) developing business cases around N-fixing crops and in general for soil fertility practices. E.g. by developing products as well as finding ways to get payment for the ecosystem services e.g. carbon credits.

Results observed

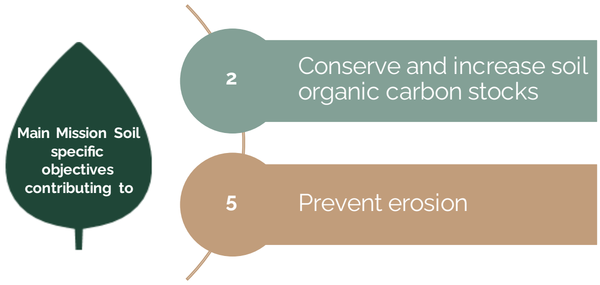
Ekoboerderij de Lingehof does not have a standardized monitoring and evaluation methodology as its choices and activities develop 'organically' overtime. Assessment methods are usually empiric and based on day-to-day tasks.

The practices applied in the past by EKO has resulted in a tremendous reduction in the need for (organic) manure input (from 170 to about 70 kg/N ha on average. The overall soil quality at the farm has also improved, we can assess this visually every time we dig in the soil and see a large amount of rainworms and a 'crumbly' soil structure in the soil in most plots. This is also visible in the soil tests.

LL1. Mediterranean Agricultural Soil - Campidano Plainand other agricultural areas of Sardinia

This chapter presents the general information of LL1; LL representatives, geoclimatic context, socioeconomic context, reference experimental site in the living lab, proposed solution, and results observed.

Summary



Coordinator partner	Agricultural research agency of Sardinia (AGRIS) and Euro Mediterranean Centre on Climate Change Foundation (CMCC)
LL name (location)	Campidano, Plain and other agricultural areas of Sardinia
Region	Sardinia
Country	Italy
Area (Ha)	20 ha
Soil health challenges	• Environmental conditions - Climate change and polluted soils in some areas • Land abandonment - Low profitability of agricultural activities. • Soil fertility reduction • Water scarcity & extreme events

LL CHARACTERISTICS

Year of establishment	In process of establishment
Nr of Reference Experimental Sites	2
Nr of Experimental Sites	9

Figure 39: Summary of general information, LL1.

LL Representatives

The Euro Mediterranean Centre on Climate Change Foundation (CMCC)'s mission is to investigate and model the climate system and its interactions with society to provide reliable, rigorous, and timely scientific results as well as foresights and quantitative analysis of our future planet and society which will, in turn, stimulate sustainable growth, protect the environment, and develop science-driven adaptation and mitigation policies in a changing climate. CMCC collaborates with experienced scientists, economists, and technicians, which work together to provide complete analyses of climate impacts on various systems such as, but not limited to, agriculture, ecosystems, coasts, water resources, health, and economics. CMCC also supports policymakers in setting and assessing costs, mitigation, and adaptation policies.

The Regional Agricultural Research Agency of Sardinia (Agris Sardegna) was established in 2006 by merging five former regional institutions dealing with different aspects of agriculture research and development. The mission of the Agency is to: foster sustainable rural development; protect and enhance animal, plant and microbial biodiversity; develop the agricultural, agro-industrial, forest and fishery sectors. Agris is involved in different activities to achieve its aims, such as research and development projects; technical and scientific advice to farmers, agri-food industries, policymakers and PDO products consortiums; training and dissemination.

Geoclimatic context

Sardinia is the second biggest island in the Mediterranean Sea with an area of 24,100 km^2. The climate of the Island is Mediterranean, with average annual precipitations ranging from 400 to 1100 mm, mainly distributed in winter and autumn with erratic heavy rainfall in spring and snowfalls in the highlands. The average temperature is between 12 and 18 °C, with mild winters and hot summers (SRACC, 2019[15]).

Socioeconomic context

Sardinia's GDP per inhabitant is 70% of the European Union average. At a national level, it ranks among the best regions in the centre-south, but the gap with the high-income northern Italian regions remains unchanged (CRENoS, 2023)[16]. The provinces of Cagliari and Sassari show the most significant rate of economic development with a good development of the industrial sector[17]. The high cost of transportation of goods and electricity, two times as much as that of the Continental Italian Regions and three times as much as that of the EU average, is the primary constraint for the Sardinian economy. In contrast, Tourism and Agri-Food sectors are two lively and vital sources of income for the Island, with sizeable room for growth. Sardinia is the only Italian region that produces a surplus of electricity and exports electricity to Corsica and the Italian mainland[18].

The economy of Sardinia Island is facing challenges due to its stagnant status, characterized by a high prevalence of small and microeconomic activities, and notable unemployment rates, especially among young people. Furthermore, the economic structure is dominated by the primary sector and an oversized services sector, with the public administration sector holding significant influence (Moro et al. 2016)[19].

Sardinian soils

The 47.9% of the land surface in Sardinia, largely mountainous and hilly, is exploited for 60% for permanent grassland and pastures, 34% for arable land, while agricultural woody crops cover the remaining 6%.

Sardinian soils show great variability due to the ancient geological origin, with small and sometimes brackish aquifers, and very small natural water reserves. The scarcity of water was the first problem that was faced for the modernization of the sector, with the

[15] https://portal.sardegnasira.it/strategia-regionale-di-adattamento
[16] https://crenos.unica.it/crenosterritorio/sites/default/files/allegati-pubblicazioni-tes/Volume%20versione%20integrale.pdf
[17] https://www.infocamere.it/movimprese
[18] https://www.istat.it/
[19] Moro, D., Sideri, M., & Usai, S. (2019). L'economia della Sardegna. Una competitività fragile. In Sardegna. Geografie di un'isola (pp. 215-227). Franco Angeli.

construction of a large system of damming of waterways that today reaches almost 2 billion cubic[20] meters of water storage capacity in reservoirs.

In Sardinia, the soil is uniquely fragile due to the island's landscape morphology and climate, making it acutely sensitive to degradation if land use changes don't sufficiently consider its inherent qualities and limitations (Vacca et al., 2002)[21].

Soil degradation is a significant issue caused by various factors, particularly anthropogenic factors. These include the removal of Mediterranean maquis, uncontrolled wildfires, overusing water resources, and abandoning traditional land management practices. Intensive farming practices can also lead to soil degradation (Zucca et al., 2010)[22].

The actions taken in the past have resulted in significant land degradation, endangering about 50% of Sardinia's land. If not addressed effectively, this could lead to irreversible degradation. (Motroni)[23]. From 2006 to 2021, the data indicates that land consumption in Sardinia has increased in absolute terms and per capita. The rise in the latter can be attributed to a decline in the resident population in the region, which suggests a less efficient use of land resources over time. When examining the provincial differences, it's notable that Cagliari, the province with the most significant increase in land consumption, also saw a parallel growth in per capita consumption (CRENoS, 2023)[24].

Reference Experimental Site of the LL1: Sardinian Conservation Agriculture Long Term Experiments (LTE)

LL1 is made up of 9 experimental sites and 2 Reference experimental sites. See more details in the sections below.

GENERAL DESCRIPTION

The core of the reference experimental sites of LL1 are two Long-Term experiments (LTE) in two sites (Ussana and Benatzu) that are only 1 km apart. It is a 20-year experiment started in 2003. Therefore, the sites share the same climate but have very different soil conditions due to the ancient pedological origin of the area. The current cropping system is conservation agriculture, applied to improve sustainability and soil fertility and soil health. The experimental design follows a split-plot design with three complete randomized blocks, allowing for systematic and controlled testing of conservation agriculture practices.

Figure 40. Distribution of Reference Experimental Sites within LL1.

[20] https://autoritadibacino.regione.sardegna.it/wp-content/uploads/2023/03/2023_03_15_dCI_04_allegato_B.pdf

[21] Vacca A., Loddo S., Serra G., Aru A. Soil degradation in Sardinia (Italy): main factors and processes. In: Zdruli P. (ed.), Steduto P. (ed.), Kapur S. (ed.). 7. International meeting on Soils with Mediterranean Type of Climate (selected papers). Bari: CIHEAM, 2002. p. 413-423. (Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 50). 7. International Meeting on: Soils with Mediterranean Type of Climate, 2001/09/23-28, Valenzano (Italy). http://om.ciheam.org/om/pdf/a50/04002055.pdf

[22] Zucca, C., Canu, A., & Previtali, F. (2010). Soil degradation by land use change in an agropastoral area in Sardinia (Italy). Catena, 83(1), 46–54. https://doi.org/10.1016/j.catena.2010.07.003

[23] Motroni A. (2019). Clima, cambiamenti climatici e desertificazione. In Sardegna. Geografie di un'isola di Andrea Corsale e Giovanni Sistu, Franco Angeli editore (pp. 21 - 31), ISBN: 9788891781390

[24] CRENoS - Economia della Sardegna. 30° Rapporto - Volume versione integrale.pdf (unica.it)

Site	Location	Soil type	Fertility	Temp.	Precip.	Main economic activities	Main crops
Ussana	39.410 N, 9.091 E, 94 m a.s.l.	Petrocalcic Palexeralf soil	Medium/ medium-low	Min: 10.8 °C Max: 23.2 °C	464 mm	• Durum wheat production for semolina • Bread- and pasta-making	• Durum wheat, • Faba bean • Proteic field pea
Benatzu	39.420 N, 9.086 E, 89 m a.s.l.	Vertic Epiaquept soil	Medium-high/ high	Min: 10.8 °C Max: 23.2 °C	464 mm		

Table 7. Main characteristics of the Reference Experimental Sites within LL1.

CHALLENGES ADDRESSED

- Environmental conditions: worsened by climate change and polluted soils.
- Land abandonment due to low profitability of agricultural activities.
- Soil fertility reduction (common to other Mediterranean areas).
- Water scarcity & extreme events: Reduced sustainability of rainfed extensive crops such as cereals, forages etc. and animal husbandry such as breeding sheep in hilly areas etc.

INTERVENTIONS

The experimental design split the plots into 3 randomized blocks where the following interventions were applied:

MAIN PLOTS (2400 m^2): Three tillage methods were implemented:

- No tillage or Sod Seeding (SS)
- Minimum or Reduced Tillage (RT)
- Conventional Tillage (CT)

These interventions were compared with conventional tillage practices.

SUB-PLOTS (600 m^2): Crop rotations methods were applied:

- Single cropping with durum wheat (CW - Continuous Wheat)
- Durum wheat/legume crop rotation (LW - Legumes/Wheat)

From 2015, changes in rotation treatments were implemented due to phytopathology problems caused by accumulation of nematodes (Foxi et al, 2017) especially with Continuous Wheat (CW) and Conventional Tillage methods.

Therefore, CW was replaced by two new rotations treatments:

- Durum wheat/faba bean rotation (FW – faba bean/wheat)
- Durum wheat/field pea rotation (PW – field pea/wheat).

These crop rotation practices allow for the evaluation of different cropping strategies and their impact on soil health, nutrient cycling, and overall agricultural productivity within the context of Conservation Agriculture.

DATA COLLECTED

In the last 20 years numerous data has been collected, mainly:

- Crop data:
    - durum wheat: grain yield and quality (moisture, protein, gluten, gluten index, 1000 kernel weight (TKW), specific weight.
    - Faba bean: grain yield, grain moisture and TKW.
    - Field pea: grain yield, grain moisture and TKW.
- Soil data: soil profiles since 2003, soil texture and chemical analysis for 2-3 layers (every 4-5 years), compaction curve.
- Crop management data.
- Meteorological and Climate data: daily Tmin, Tmax, Prec, Solar radiation from locally placed field weather stations.

In addition to chemical aspects, the following data was also collected:

- Soil organic matter (SOM) in CW and LW
- Penetration resistance
- Presence of Pathogens

RESULTS

After implementing Conservation Agriculture Practices for 10 years, the following main results were observed:

- No difference in crop yield on durum wheat
- Increase of soil organic carbon in the medium-long term period
- Mitigation of GHG emissions due to a reduction of the use of fossil fuels as well as an increase of soil organic carbon
- Reduction of phytopathology problems (nematodes) especially with continuous wheat and conventional tillage methods based on mouldboard plough.

Experimental Sites of the LL1

Ll1 includes several farms in the Campidano plain area and in the North of Sardinia region. A total of 9 experimental sites were selected: 7 sites are related to cereal cultivation, 1 to olive trees and 1 to vineyard. The table below summarizes the information on the selected experimental sites, treatment and planned sampling campaigns.

The sites and the sampling design may be subject to changes depending on the development of the project and the criteria established with the coordinators of the involved WPs.

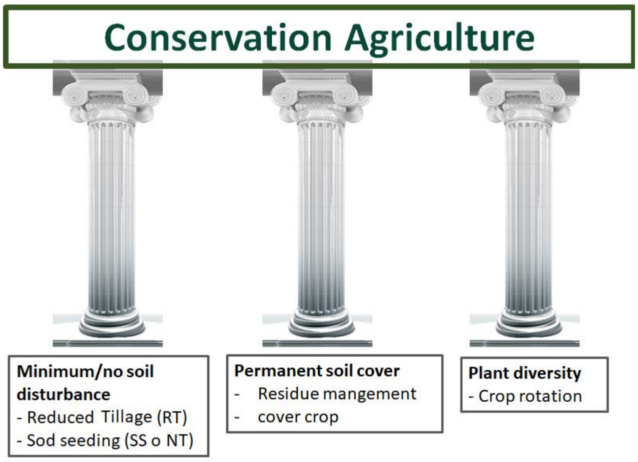
Municipality	ID	Crop	Treatment (Tillage)	Sample year 2023	Sample year 2025
Sanluri	**SS1**	Durum wheat	Sod seeding	x	
	RT2	Durum wheat	Reduced tillage	x	
	CT3	Durum wheat	Sod seeding from conv. tillage	x	x
Samatzai	**SS4**	Durum wheat	Sod seeding	x	
	RT5	Durum wheat	Reduced tillage	x	
	CT6	Durum wheat	Sod seeding from conv. tillage	x	x
Guspini	**SS7**	Durum wheat	Sod seeding	x	

Capoterra	ORG8	vineyard	Organic (plus grassing)	x	x
Sorso	RT9	olive	Organic (No tillage & shredding)	x	x

Table 8. Experimental sites characteristics in LL1.

LL focus area: Conservation agriculture

LL1 in Sardinia focuses on Conservation Agriculture (CA) and sustainable crop management over cereals, olives and vineyards, and tests CA techniques based on the learnings from the existing Long-Term Experiments in the sites selected.
Conservation Agriculture is based on three pillars aiming at:



- Minimizing or avoiding soil disturbance through reduced tillage and sod seeding.
- Maintaining permanent soil cover through residue management and cover crops.
- Promoting plant diversity through crop rotation.

These practices aim to preserve soil health, prevent erosion, and enhance sustainability in agriculture.

Conservation agriculture offers several advantages, including:

Reduced erosion	Mitigates greenhouse gas emissions
Improved soil structure, Organic matter content, and fertility	Stabilizes yields
Conservation of soil water content	Helps maintaining cultivation in disadvantaged rural areas
Reduces cultivation costs	Enhanced sustainability of agricultural activities

Table 9. Advantages of conservation agriculture in LL1.

These benefits contribute to the preservation of soil health, environmental sustainability, and the long-term viability of agricultural systems.

Challenges to be addressed

The main challenges to be addressed both in the Reference Experimental Sites and LL1 are:

- Environmental conditions: worsened by climate change and polluted soils.
- Land abandonment due to low profitability of agricultural activities.
- Soil fertility reduction (common to other Mediterranean areas).

- Water scarcity & extreme events: Reduced sustainability of rainfed extensive crops such as cereals, forages etc. and animal husbandry such as breeding sheep in hilly areas etc.

Stakeholder community

- The stakeholder community of LL1 involves about 70 members, including 20 farmers and key stakeholders from other categories: public administrations, private sector, farmer organizations, civil society, academia, and research.
- This wide stakeholder network was built over time starting from long-term collaboration established in the area. The network of relevant stakeholders is well established as many stakeholders collaborate in different research projects on similar topics and it is continuously expanding to support the achievement of InBestSoil project-specific results.

Potential Activities

- Test benefits from new soil management strategies implemented in two experimental sites.
- Evaluate the sustainable soil management strategies of the farms already applying such strategies to demonstrate to other farmers the advantage of applying them from a physical, ecological, and economic point of view.
- Raising farmers' awareness of soil health issues.
- Informing farmers about the potential long-term benefits of applying conservation agriculture for the soil health and the sustainability of this management.
- Exchange of experiences between farmers practising conservation agriculture and those still practising conventional tillage based on ploughing through technical meetings and open field days.

Monitoring & Impact

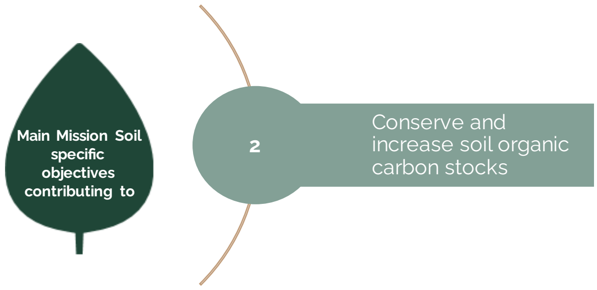
The LTE Reference Experimental Sites will be used as a solution demonstration, training, and communication to farmers example within the Case Study. These serve as a platform to showcase innovative solutions, provide training programs, and facilitate effective communication channels for farmers, fostering knowledge exchange and the adoption of sustainable practices in agriculture.

Special attention will be dedicated to ensuring the engagement and participation of the different stakeholders of the LL. More specifically, periodic meetings are planned with the farmers to constantly guide them in the implementation/evaluation of sustainable soil practices. Farmers will be supported in each phase of the project's activities to enhance farmers' motivation, build trust in sustainable soil management practices, and strengthen the collaboration between farmers, academia, and policymakers. The goal is to give impulse for a permanent LL for agriculture Mediterranean soils as a meeting point for sharing experience, training, improving capacity building, discuss, and for being more incisive in the market.

LL2. Temperate Agricultural Soil – Climate protection through humus build-up, Cantons of Basel, Switzerland

This chapter presents the general information of LL2; LL representatives, geoclimatic context, socioeconomic context, LL2 structure, LL2 focus area, reference experimental site, potential activities/interventions, monitoring & Impact.

Summary



Coordinator partner	Research Institute of Organic Agriculture (FIBL)
LL name (location)	Climate protection through humus build-up
Region	Cantons of Basel
Country	Switzerland
Area (Ha)	1100 Ha
Soil health challenges	Reduced organic inputs, strong temperature increase

CASE STUDY CHARACTERISTICS

Year of establishment	2020
Nr of Reference Experimental Sites	2 (selected out of 10)
Nr of Experimental Sites	10 (selected out of 55)

Figure 42: Summary of general information, LL2.

LL representative

The Research Institute of Organic Agriculture FiBL is one of the world's leading institutes in the field of organic agriculture. Its locations are situated in Switzerland, Germany, Austria, Hungary (ÖMKi), France and a representation in Brussels (Belgium) through FiBL Europe. FiBL's strengths lie in its interdisciplinary research, innovations developed jointly with farmers and the food industry, solution-oriented development projects and rapid knowledge transfer from research into practice. FiBL is a member of the ENoLL network since 2021.

In the context of InBestSoil project, FiBL will focus on evaluating the impact of carbon farming initiatives and testing new interventions through the Baselland Canton Case Study in Switzerland.

Geoclimatic context

The cantons of Basel with an area of 51.800 ha, is located in the northwestern part of Switzerland. Basel-Binningen (47.54 N / 7.58 E) and Rünenberg (47.43 N / 7.88 E) show an annual mean temperature of 10.5 °C and 9 °C. The annual precipitation is 842 mm and 1.009 mm, respectively (Bundesamt für Meteorologie und Klimatologie MeteoSchweiz, 2021, 2020).

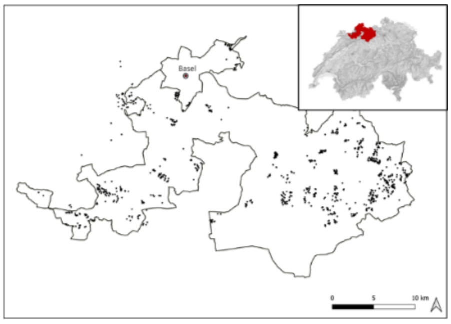


Figure 43. LL2 location map.

Socioeconomic context

Ll2 is situated in the economic region of Basel that includes parts of France and Germany as well. Since the 1960s there are agreements in force to strengthen contacts within the so-called Regio Basiliensis. This economic co-operation is often considered the most intensive in Europe.

From the 17th century until the beginning of the 20th century silk weaving was important in the region. Factories were established as early as 1850, following the finding of salt in underground deposits, founding industries such as the chemical industry. Today, the economic region of Basel is considered the second largest economic centre in Switzerland, after Zurich. The chemical industry and the pharmaceutical industry are of greatest significance in the canton. There are a number of multinationals in the cantons of Basel, attracting workers from both cantons of Basel and the areas across the border in France and Germany. Banking and finance are important as is the service sector in general. Small and middle-sized businesses employ a significant number of people, both in the city as the two municipalities. The canton is also known for its banking sector, and for being the worldwide seat of the Bank for International Settlements.

Agriculture in the canton includes fruit growing, dairy farming and cattle breeding, but is of minor importance for the GDP.

Soils in canton Basel-City and Basel-Country

About 41% (21,423 ha) of soil in the canton of Basel-Landschaft is agricultural land, of which 54 % is grassland, 43 % is arable land and 3 % is special cultivated land[25].

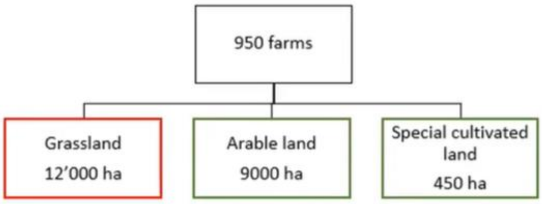


Figure 44. Structure of LL2.

The geology is dominated by three tectonic units that formed during the Tertiary: The Upper Rhine Graben, the Tafeljura and the Faltenjura. The Tafeljura and Faltenjura consist of solid limestone, marl, and clay sediments of the Mesozoic era. The Upper Rhine Graben was filled with deposits of continental and marine sediments formed by calcareous sandstones, conglomerates, marls, and clays (Amt für Umweltschutz und Energie). Aeolian sediments (mainly silt, often clayish and calcareous) were deposited since the middle Pleistocene, forming loess layers of up to 17 m thickness in the western part of the canton of Basel-Landschaft[26 27]. In the same period, glacial- and fluvial transport led to deposits of gravel and sand to silty material in valleys, whereby fluvial processes occur until today and form the alluvions (Bitterli-Brunner, 1988). Dominant soil types in the

25 Statistisches Amt des Kantons Basel-Landschaft, 2022.

26 https://www.researchgate.net/publication/319877708_Middle-Pleniglacial_soil_formation_MIS_3_in_the_Upper_Rhine_Graben_The_loess-palaeosol_sequence_of_Basel-Schaublinstrasse_Switzerland

27 Zollinger G (1991): Die Loessdeckschichten der Ziegelei in Allschwil (Kanton Basel-Landschaft, Schweiz). Ein Beitrag zur Quartaerstratigraphie am suedlichen Oberrheingraben

region are Eutric and Calcaric Cambisols, Haplic Luvisols, and Stagnic Cambisols[28]. The altitude rises from north to south, from 245 to 1,150 m.a.s.l.

LL2 Structure

Since January 2021, the Ebenrain Center for Agriculture, Nature and Food (Ebenrain) has been implementing the project "Climate protection through humus build-up", in collaboration with Bio-Nordwestschweiz and the Research Institute of Organic Agriculture (FiBL) in Frick. Together, the partners are pursuing two major goals:

1. Make agricultural soils more adaptable to drought and thus more resilient to climate extremes by building up humus.
2. Increase C sequestration from the atmosphere in agricultural soils.

The aim is to increase the humus content over 6 years on 55 farms with a total project area of 1100 ha in the cantons of Basel-Landschaft and Basel-Stadt. The project is scientifically accompanied by FiBL, and an advisory group with representatives from the Basel Farmers' Association (BVBB), farmers and Ebenrain experts is supporting the project.

A cantonal bank (Basellandschaftliche Kantonalbank) supports the project through a regional compensation mechanism. In this way, BLKB aims to compensate 1000 tons of greenhouse gas emissions in regional agriculture.

Key actions on the participating farms are:

- Three farm-specific consultations during the project period. During the first visit a farm-specific SOM build up plan is developed to be conducted during the whole project duration.
- Analytical measurements of the humus content in the 1st, 3rd and 6th year.
- Impact-oriented compensation of the carbon sequestration.

Out of the 55 participating farms 10 have been selected for the InBestSoil project interventions and in-depth sampling campaigns.

LL2 focus area

The aim of LL2 is to adapt agriculture to climate change in order to strengthen soil resilience and soil fertility towards climate extremes, and also, to provide food security in the future. Farmers' awareness for the detrimental effects of climate change on agricultural production is high in the region. This is reflected in a self-organised and -moderated farmer working group on soil organic matter management. Farmers, regional agricultural school and advisory service, research institutions and private business agreed to increase the humus content of the soil, positively impacting soil fertility and and climate change adaptation. This is the common understanding that led to the development of the project including compensation payments.

Reference Experimental Sites of the LL2

GENERAL DESCRIPTION

The DOK field experiment is a long-term farming system comparison trial, located in Therwil, Canton of Basel Landschaft, Switzerland (7◦32' E, 47◦30' N), which started in 1978. The soil type is a Haplic Luvisol[29], developed on alluvial loess. The mean annual

[28] IUSS Working Group WRB. 2022. World Reference Base for Soil Resources. International soil classification system for naming soils and creating legends for soil maps. 4th edition. International Union of Soil Sciences (IUSS), Vienna, Austria.

[29] WRB, IUSS & Schád, Péter & van Huyssteen, Cornie & Micheli, Erika. (2015). World Reference Base for Soil Resources 2014, update 2015.

temperature is 10.5 ◦C (1.5 ◦C increase since 1978) with a mean annual precipitation of 840 mm[30].

This trial investigates the differences between the biodynamic (BIODYN), organic-biological (BIOORG) and conventional (CONFYM) agricultural systems since 1978. The trial simulates farms with mixed crop and livestock production. The exclusively mineral-fertilised, conventional system (CONMIN) stands for livestock-free agriculture. In the BIODYN, BIOORG and CONFYM systems, manure and slurry are applied according to 1.4 livestock densities.

The research results on arable farming, soil fertility, nutrient supply, biodiversity, and climate relate to five different crops that are currently grown alternately as part of the seven-year crop rotation: Silage maize, soybeans, winter wheat, potatoes, and clover grass. The results of 42 years of research have been published in scientific journals and are also of great interest for agricultural practice.

CHALLENGES ADDRESSED

The DOK trial is designed as a system comparison trial considering mainly different fertilisation and pest control strategies, which reflects the general trend in shifting food systems and changing climatic conditions.

INTERVENTIONS

In the DOK trial, two organic and two conventional farming systems are compared with an unfertilized control[31]. They have the same crop rotation within seven-year crop rotation periods (CRP) with two years of grass-clover ley but receive different types of fertilisers. Each farming system is replicated four times (columns), and the crop rotation is running temporally shifted in three subplots. This sums up to 96 parcels (5 × 20 m each), arranged in a randomized split-block design. All farming systems have the same type and frequency of tillage but receive different types of plant protection.

DATA COLLECTED

In the DOK trial fundamental agronomical, ecological, and economical parameters are assessed on a regular, at least annual basis since 1978. In addition, all sampled materials are archived and available for additional experiments. Measuring and sampling campaigns for more specific scientific questions are conducted continuously.

RESULTS

During the 42-year field experiment, organic systems used 92% less pesticides and 76% less available nitrogen than conventional systems in an arable rotation. Measurements over the whole experimental period show that nitrogen use efficiency, including biological nitrogen fixation, was above 85% for all systems. Organic systems covered nitrogen export of crops due to nitrogen fixation by legumes in the rotation, and the amount of fixed nitrogen exceeded the fertilizer nitrogen. Organic fertilization with farmyard manure at 14. LU ha-1 maintained or raised soil carbon and nitrogen stocks on the long term, with an increase in systems with manure compost, and a decrease with exclusively mineral fertilizers. Soil based climate impact was mainly driven by N2O emissions and was 56% lower per hectare in organic systems in a measurement period covering grass-clover, maize, and green-manure. Organic cropping systems showed enhanced soil quality, and richness of micro- and macrofauna. Despite a rigorous reduction of inputs yields of the organic systems achieved 85% of the conventional systems. Highest yield gap was

[30] Krause, Amanda. (2020). The Role and Impact of Radio Listening Practices in Older Adults' Everyday Lives. Frontiers in Psychology. 11. 603446. 10.3389/fpsyg.2020.603446.
[31] Mader, B.T., Flagan, R.C. and Seinfeld, J.H. (2002). Airborne measurements of atmospheric carbonaceous aerosols during ACE-Asia. Journal of Geophysical Research 107: doi: 10.1029/2002JD002221. issn: 0148-022

observed for potato, followed by wheat, maize, and grass clover, while similar yields were observed for soya.

LL2 Challenges to be addressed

The Case Study goals are:

- To improve carbon sequestration and soil fertility in arable soils by increasing humus content.
- To improve yield stability by increasing water holding capacity.
- To introduce and test the impact-based compensation system for the increase of SOM.
- To assess the potentials of IR spectroscopy to measure SOM and allow in-field advisory services.

Potential Activities/Interventions

The measures will be discussed individually on each farm and can include, for example:

- Year-round soil coverage
- Crop residues: retention, recycling, incorporation.
- Organic fertilizer: manure, slurry, compost, digestate, pomace.
- Balanced and diverse crop rotation.
- Reduced tillage.
- Ground cover in orchards and vineyards.
- Hedges, field copses, agroforestry.
- Biochar application to soils.

Monitoring & Impact

All 705 plots on 55 farms are sampled and analysed for SOC stocks in the 1st, 3rd, and 6th year of the project.

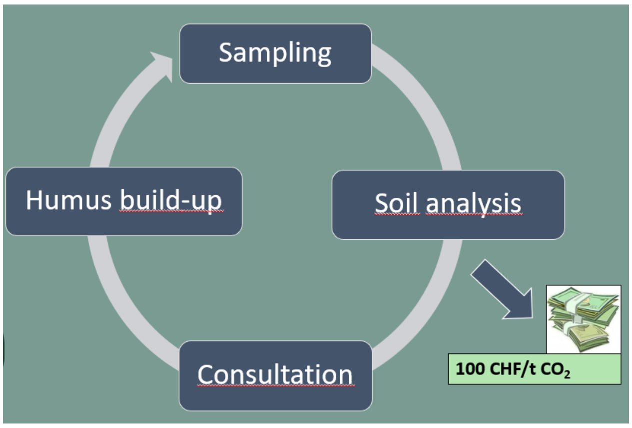


Figure 45. LL2 intervention process and monitoring.

50 plots of the 10 focus farms are sampled and analysed every year during the whole project duration, as well as analysed for SOC stocks and further characteristics of SOC dynamics. In addition, GIS studies on natural and socio-economical driving factors of SOC dynamics are continuously monitored. IR spectroscopy is continuously evaluated as a rapid, cheap and precise monitoring tool for SOC dynamics in the lab and field (MRV for carbon compensation projects). The focus farms are also monitored for the effects of the interventions on yield stability and biodiversity.

All 55 farms in the Case Study are contributing to annual project meetings, and 20 farms are part of a working group on soil organic matter and meet monthly. There is also vivid and regular exchange with two other compensation/climate mitigation projects in Switzerland, as well as loose exchanges with other cantonal soil management projects.

Stakeholder identification and mapping

Introduction to methodology

Stakeholder identification and mapping is a crucial step to understand and address the various stakeholders that will be involved during InBestSoil lifetime and beyond. Through this process, the project aims to identify and analyse the key actors who may impact or be impacted by the project: by understanding their roles, interests, and needs, we can establish effective communication, foster strong collaborations, and make informed decisions that promote the success and sustainability of InBestSoil, as well as to facilitate the co-creation tasks within the project.

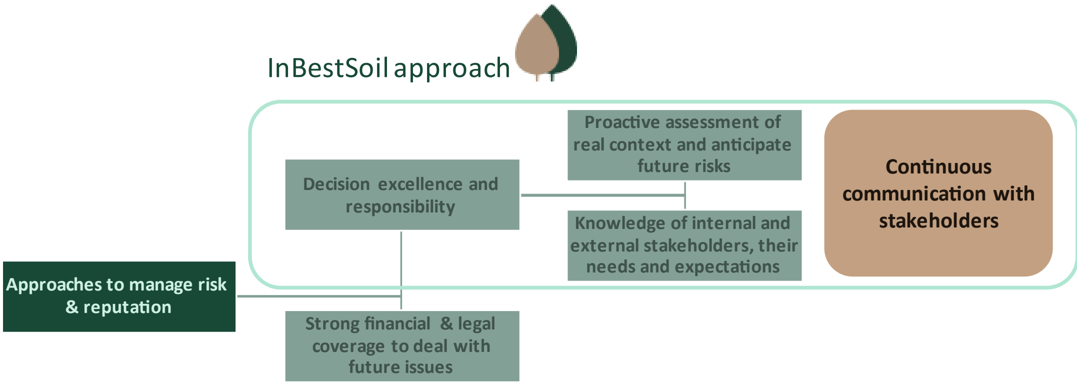


Figure 46. InBestSoil stakeholder engagement approach.

As described in the previous section (InBestSoil LH and LLs: A context narrative), InBestSoil counts with representatives from 7 Lighthouses (LH) and 2 Living Labs (LL) in its consortium, to ensure access to the different case studies and effectively deliver on project results, including a diverse stakeholder profile network.

The relationship between projects and their stakeholders usually has a progressive evolution. InBestSoil aims to evolve from the identification and mapping of stakeholders to phases where they can be involved in decision making processes (WP3-WP4), including strategies and policies (WP5-WP6):

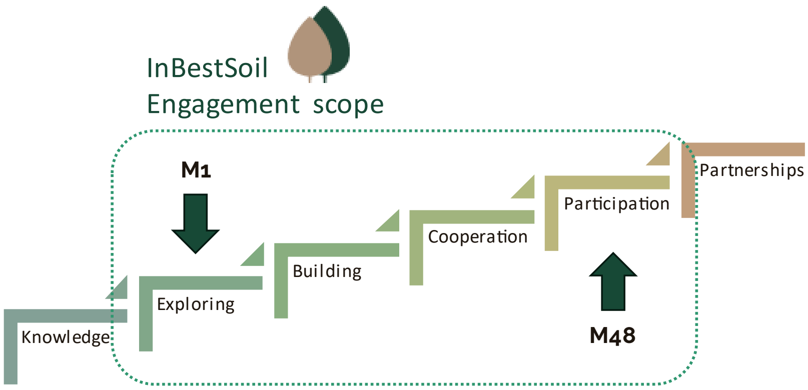


Figure 47. InBestSoil engagement scope.

InBestSoil will follow 5 steps (figure 47) to engage with its stakeholders in the LH and LL included in the project but also, with external stakeholders such as sister projects and other Mission Soil projects including umbrella projects PREPSOIL and NATI00NS, EU wide initiatives (EUSO etc.) and international experts as needed.

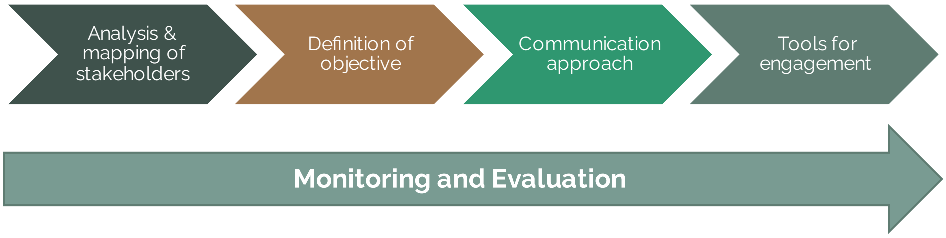


Figure 48. InBestSoil engagement steps.

Definition of the objective

Participation of key stakeholders in Mission Soil projects is essential to ensure the "Awareness of soil issues is key to ensuring active position/participation and involvement on the part of interested parties in activities and initiatives related to soil health" [32].

The objective therefore is to inform, consult, involve, and collaborate with key stakeholders within the LH and LLs included in the project as well as external ones to ensure that project results meet and respond to real needs and challenges. Specifically, InBestSoil will engage with stakeholders to:

1. Co-defining SOIL HEALTH INDICATORS for each Ecosystem Service, responding to land users, managers and/or policymakers´ priorities and needs (WP3).
2. To assess the benefits and barriers for CARBON FARMING and which measures would benefit land users (WP4).
3. Understanding which BUSINESS MODELS and INCENTIVES best support land users would and/or managers that decide to implement sustainable practices (WP5)
4. Understanding and finding solutions to BARRIERS and NEEDS already identified by land users, managers, or policymakers in terms of implementing sustainable practices (WP4-WP5).
5. To understand the role of small-scale INNOVATIONS LED BY FARMERS (or LAND USERS), to adapt existing technologies to agri-ecological practices (WP4 – WP5).
6. To propose new POLICY measures that can support FARMERS´ and LAND USERS or MANAGERS transition to best soil health practices (WP6).

To meet this objective a roadmap on how to analyse, monitor and manage each of these co-creation activities within the project is being developed in the following deliverable: *D2.3 Co-design and co-creation plan for InBestSoil (M20).*

The analysis and mapping of stakeholders will ensure that a sufficient, diverse, and meaningful representation and participation of stakeholders is included in the delivery of project results. By identifying key stakeholders, InBestSoil will consider the input and feedback from these groups of interest from early stages of the solutions development process ensuring a better understanding and integration of these approaches in the different soil types and land uses represented in the project.

The steps that InBestSoil follows to analyse and map its key stakeholders are:

[32] European Commission, Directorate-General for Research and Innovation, *Communication and citizen engagement initiatives in line with the Horizon Europe Mission A Soil Deal for Europe – Report on dissemination and exploitation practices in Member States and associated countries*, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2777/704413

1. Pre-identification of stakeholders (M8)

In this case a pre-identification of main local stakeholders was carried out for each LH and LL but also, outside the project. These stakeholders are considered to potentially have an impact on or be impacted by the project.

During this exercise, various aspects for each stakeholder were analysed such as their profile, nature of their activity, contact details as well as their preferred communication means and format. This information has helped to determine the specific role they might play as stakeholders in the project and beyond, and to establish effective ways of communication to foster productive relationships within the project lifetime.

The characterization of stakeholders aims to establish the most efficient way to carry out the stakeholder identification process and mapping, as well as to understand their interest in participating in the project including their preferred communication methods.

3. Mapping stakeholders (M18)

A map of all the identified stakeholders has been created according to the influence they have in the project and the impact the project may have on them. To develop the map, the following questions have been posed:

- Have all stakeholders related to InBestSoil been identified?
- Who are the stakeholders who have the most influence on the project?
- Who are the stakeholders that will be more affected by the project?

The map has been built using an impact matrix (figure 49), adapted from Ackermann & Eden (2011, p.183):

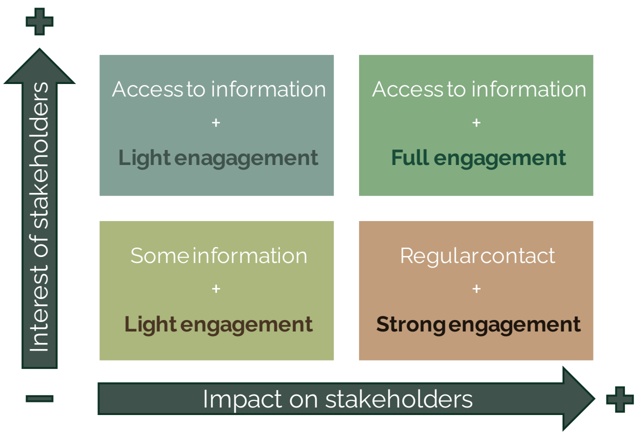


Figure 49. Stakeholder engagement Impact matrix.

According to this prioritisation method, two classification parameters were defined:

- Influence: the relevance of the stakeholder in the project and how stakeholder's actions and/or behaviour can change the course of action of the LL/LH.
- Interest: potential willingness of the stakeholder to be informed and participate in the activities, based on how its affected by the activities of the LL/LH.

After analysing the values given by each case study to each stakeholder group, actors will be classified and positioned in an influence/interest matrix.

InBestSoil LH and LL stakeholder identification and mapping

As explained in the methodology chapter, during the first months of InBestSoil, two streams related to stakeholder engagement were carried out:

- A preliminary analysis of potential stakeholders for each LH and LL, that has continued until M18 to complete T2.1 and update the information generated at the start of the project.
- Characterization of stakeholders to stablish the most efficient way to carry out the stakeholder identification process and mapping, as well as to see their interest in participating in the project,

It was agreed with project partners to first collect all the data related to the already "known" stakeholders by each LH and LL representative. This led to a list of approximately 280 contacts that currently represents the main contact list for InBestSoil. These stakeholders were contacted via email with a short presentation of the project and an invitation to complete a survey[33] where they could indicate their interest in participating in the project.

From these contacts, 105 stakeholders have shown interest in participating in the project. When it comes to the communication channels to be used, most stakeholders prefer to be contacted via email although there is also a preference for face to face or online meetings, when possible. Most respondents are able to communicate in English, although a good number indicated that they would need local language translations. Interest from stakeholders from outside "InBestSoil" has also been identified, which opens further opportunities for collaboration beyond the scope of the project too.

As of today, the list of stakeholders by LL/LH has been refined to a total of 213. Once the stakeholders had been clearly identified for each case, they were **classified into the following groups:**

- **Academia /Research organisation**: Institutions primarily engaged in research, education, and knowledge dissemination. This includes universities, research institutes, and other educational organizations dedicated to advancing knowledge and understanding in various fields.
- **Business company:** This category encompasses companies across all sectors and industries, including small and medium-sized enterprises (SMEs).
- **Land Manager:** Individuals or organizations with authority or responsibility for managing land resources. This includes landowners who have the capacity and legal rights to make decisions regarding land use, conservation, and development.
- **Farmer / Breeder:** Individuals or entities engaged in agricultural activities such as cultivation, production, and breeding of crops or livestock. Farmers and breeders play a crucial role in food production and agricultural sustainability. *
- **Public Bodies**: Governmental entities or agencies responsible for public administration and governance at various levels (local, regional, national).
- **Civil Society Organisation:** Non-governmental entities representing the interests of citizens and communities. This includes local community groups, non-governmental organizations (NGOs), and public and private not-for-profit (NFP) organizations.

[33] https://forms.office.com/e/g653VrtMqi

***NOTE:** It's important to note that in many cases, farmer and breeders are also land managers.

Once the preliminary identification of stakeholders had been completed, a **Prioritization Matrix** in collaboration with case study coordinators to evaluate each stakeholder's influence and interest in the project. To accomplish this, a pre-identified list of stakeholders was shared with the case study coordinators. Each coordinator assigned a value from 0 to 2 to each stakeholder category based on their economic, social, or environmental **influence**, as well as their **impact** on each case study:

- **Influence:** How much (economic, social, environmental) influence does this stakeholder exert on the activities of the LL/LH?

  0: No influence

  1: Some influence

  2: Strong influence

  NA: Don't know or not applicable

- **Impact:** How affected is this stakeholder by the activities of the LL/LH?

  0: Not affected

  1: Somewhat affected

  2: Very affected

  NA: Don't know

This raw data was used to categorise each stakeholder group in their respective LH/LL:

Stakeholder category	Stakeholder description	*How much (economic, social, environmental) influence does this stakeholder exert on the LL/LH activities?*			How affected is this stakeholder by the activities of the LL/LH?
		ECONOMIC	SOCIAL	ENVIRON.	
Business Company	Company name	*Insert 0,1,2 or NA here*	*Insert 0,1,2 or NA here*	*Insert 0,1,2 or NA here*	*Insert 0,1,2 or NA here*
Land manager	Land manager name	*Insert 0,1,2 or NA here*	*Insert 0,1,2 or NA here*	*Insert 0,1,2 or NA here*	*Insert 0,1,2 or NA here*
Farmer/Breeder	Farmer/breeder name	*Insert 0,1,2 or NA here*	*Insert 0,1,2 or NA here*	*Insert 0,1,2 or NA here*	*Insert 0,1,2 or NA here*
Public Bodies	Public body name	*Insert 0,1,2 or NA here*	*Insert 0,1,2 or NA here*	*Insert 0,1,2 or NA here*	*Insert 0,1,2 or NA here*
Civil Society Organizations	Civil society organization name	*Insert 0,1,2 or NA here*	*Insert 0,1,2 or NA here*	*Insert 0,1,2 or NA here*	*Insert 0,1,2 or NA here*

Table 10. Template table for inserting influence and impact values for each stakeholder groups in LH/LL-s.

After analysing the values provided by each LH and LL, stakeholders were classified and positioned in an influence/interest matrix.

The **prioritization matrix** is a valuable tool for crafting a nuanced communication strategy aimed at sustaining the engagement of key stakeholders. It classifies stakeholders into four distinct categories to optimize communication efforts:

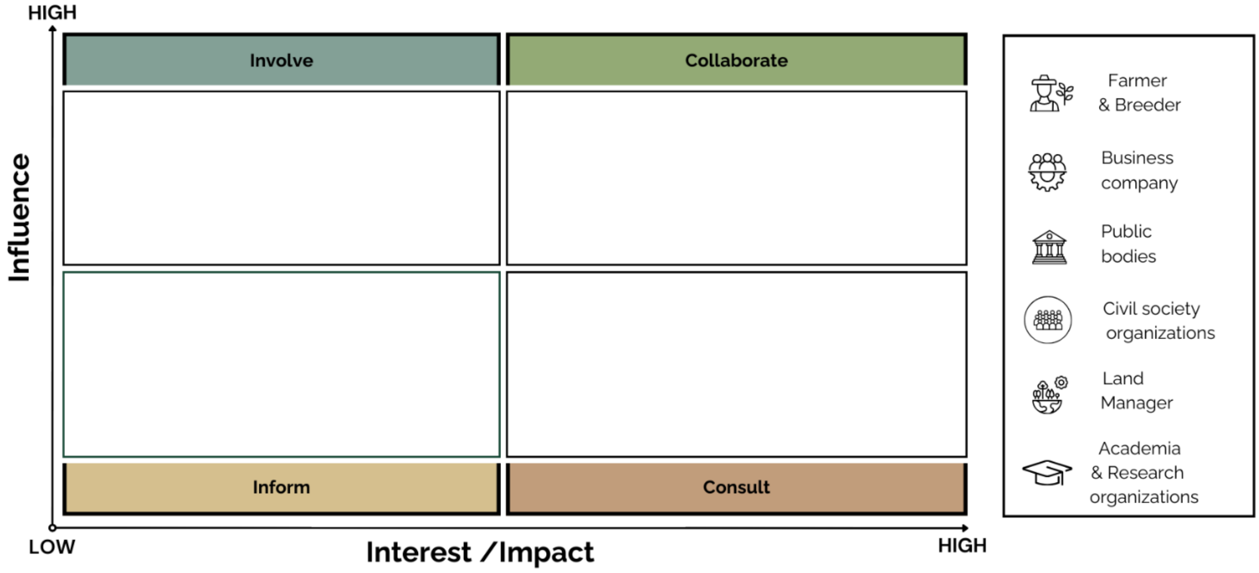


Figure 50: Stakeholder matrix develop using CANVA in ZABALA consulting.

- **Involve:** Stakeholders in the High Power-Low Interest quadrant possess considerable influence over the project but might not be highly interested in it. Although their direct involvement may not be essential, LL/LH coordinators should keep them informed and engaged to maintain their backing and avert any potential conflicts or opposition.
- **Inform:** The Low Power-Low Interest quadrant comprises stakeholders with limited influence and minimal interest in the project. While their engagement might not be critical, LL/LH coordinators should keep them informed to ensure transparency and prevent any unforeseen negative repercussions.
- **Consult:** Stakeholders in the Low Power-High Interest quadrant may lack substantial influence but have a strong interest in the project. LL/LH coordinators should actively engage with them to address their concerns, gather useful insights, and foster positive relationships.
- **Collaborate:** The High Power-High Interest quadrant includes stakeholders with significant influence and a keen interest in the project's outcomes. These stakeholders are vital to the project's success and need active engagement and collaboration. LL/LH coordinators should prioritize their communication and involvement to ensure their needs are met and their concerns are addressed.

The data collected from each LH and LL has been used to develop the following insights and interpretations, but it will be kept confidential following data protection standards and the project data management plan. It will be available upon request from the European Commission and project partners, subject to LH and LL stakeholders' consent.

Stakeholder identification and mapping: results

Below we present the results of the identification and analysis of the stakeholders in each of the LL/LH, as well as their engagement impact matrix and its interpretation.

LH1. Mediterranean Forestry Soil - Dehesa El Baldío de Talaván (El Baldío) Stakeholder groups identified and classification.

Stakeholder Distribution in LH1

LH1, "Dehesa El Baldío de Talaván," is connected to numerous **stakeholders, 69** in total, divided into the following stakeholder groups (figure 51):

- **Civil society organisations (30%):** This group has the highest number of representatives in LH1, constituting 30% of the existing total stakeholders. Most of them are environmental NGO-s, but there are also a few local community groups. This group is essential in the soil health context to ensure that soil health management is participatory and inclusive.
- **Farmers and breeders (29%)** Totally, there are 20 farmers or breeders directly affiliated with El Baldío de Talaván. Most participants in this stakeholder group are breeders managing the extensive agrosilvopastoral system of dehesas.
- **Academia and research organizations (22%)**: LH1 has significant connection with various universities and research institutions, which include both local and non-local entities.
- **Public Bodies (15%)**: These group of stakeholders includes local, regional and public organizations within the area.
- **Business companies (4%):** It represents the smallest group of stakeholders, with only 3 connections. Within this group, there are three companies, including a couple of cooperatives that support farmers and a company that is involved in meat commercialization**.**

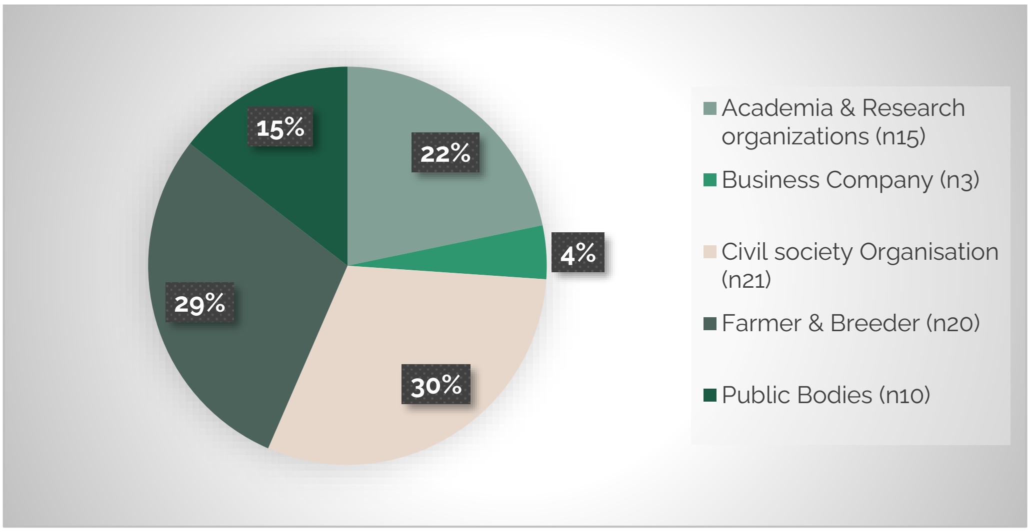


Figure 51: Stakeholder groups distribution (%) in LH1.

Stakeholder engagement impact matrix

The stakeholder matrix for LH1 shows **two primary trends** among stakeholders (figure 52):

Farmers & breeders, civil society organizations, public bodies, and academia are the most relevant stakeholder group connected to LH1. They all are in the consult quadrant, showing high interest for the project and its goals and having a high potential to increase their influence in the project and to be included in the collaborate quadrant.

The business company group shows lower interest than the rest of the stakeholder groups, which might result in lower engagement potential. However, it is still relevant to keep them well-informed and explore opportunities for better engagement. Maintaining the involvement of all stakeholder groups is crucial for the goal of creating a comprehensive living lab**.**

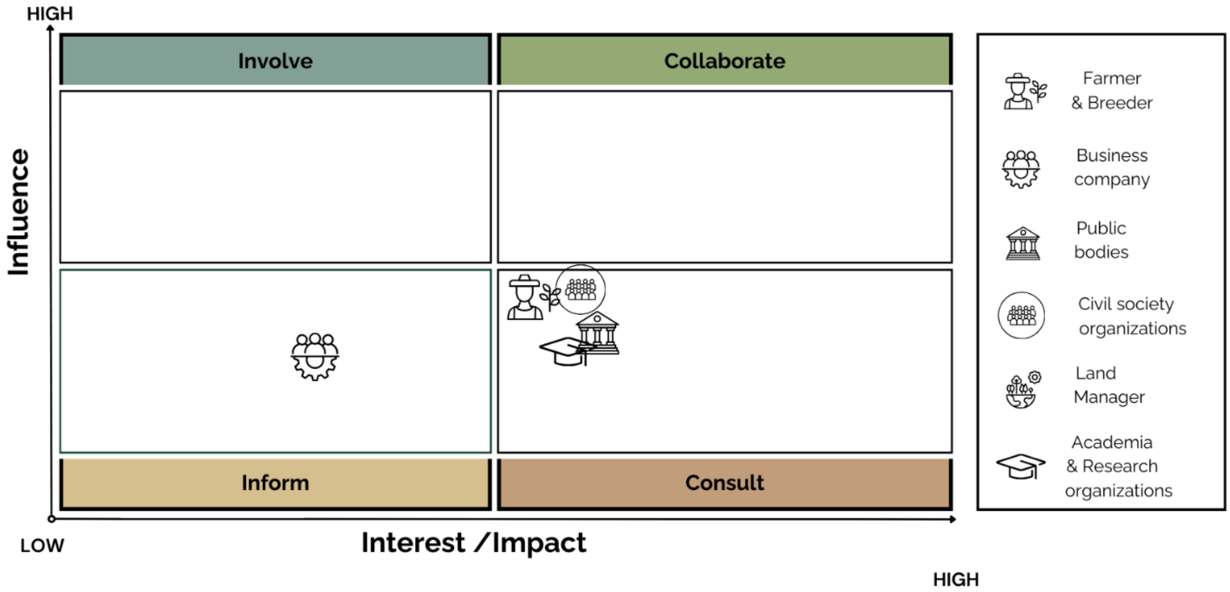


Figure 52: Stakeholder matrix of LH1.

Stakeholder map and InBestSoil co-creation activities

In this initial lighthouse initiative, both Fundación Global Nature and ACTYVA Cooperative Society have effectively engaged with numerous stakeholders in the area. To ensure continued stakeholder involvement in the project, one strategy is to incorporate them into the co-creation plan.

Analysis of the stakeholder matrix reveals that most groups, including farmers & breeders, civil society organizations, public bodies, and academia, are already closely aligned with this collaboration. Therefore, facilitating their participation in project activities can significantly enhance their engagement.

Certain individual stakeholders, such as Merinenado Farm and Álvaro Ocaña from the farmers stakeholders' group (Anex II-LH1), are already closely collaborating with LH1. These stakeholders are actively implementing sustainable and innovative practices on their farms and maintain close ties with LH1. Similar situations exist within other stakeholder groups, such as the Reserve of Biosphere of Monfragüe within public bodies. These examples highlight the establishment of a robust community of stakeholders with substantial potential for collaboration.

LH2. Mediterranean Industrial Soil - Mining district of Cartagena - La Union

Stakeholder Distribution in LH2

LH2 is connected to **10 stakeholders**. figure 54 shows the percentage of each stakeholder group, as well as the number of individual actors in each group:

- **Civil society organisations (30%):** There are 3 different types of not-for-profit organizations in this group. One environmental group, *Association of Naturalists of the Southeast (ANSE);* one foundation with the goal of promoting the development of the area; *Minera Foundation;* and one Neighbourhood Association, *Santa Bárbara Llano del Beal.*
- **Academia/ research org (30%)**: With the same percentage as the previous stakeholder group, we have 3 entities: the *Polytechnic University of Cartagena* (coordinator of this LH), the *Centre for Soil Science & Applied Biology of Segura* and the *Marble Technology Centre.* Organizations in this category represent the scientific knowledge and the capacity to study the consequences of the restoration as well as divulgating among scientist the solution.
- **Public bodies (30%)**: In this category we have two local entities, representing the two municipalities nearby, the *City council of La Union* and the *City Council of Cartagena.* The regional government of the autonomous community of Murcia is algo present in this group.
- **Land managers (10%):** It represents the smallest group of stakeholders, with only one member. It includes the company that owns the land, called Portman Golf. This is a mining company that owns the land since 1991.

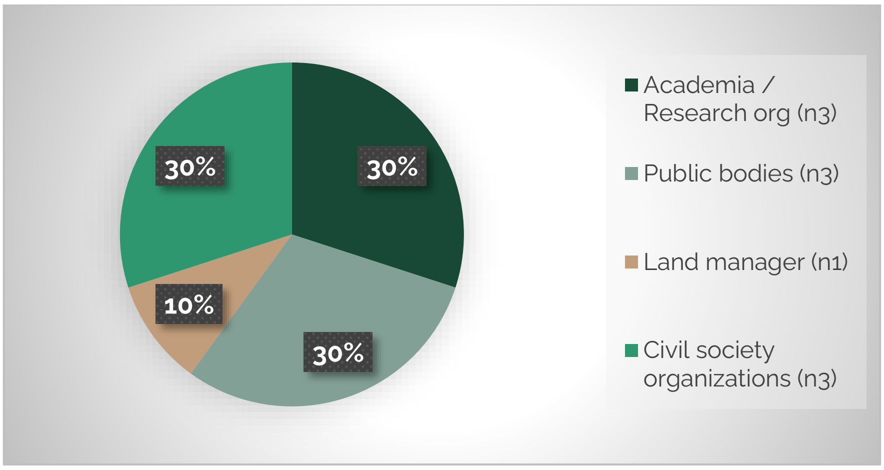


Figure 53: Stakeholder groups distribution (%) in LH2.

Stakeholder engagement impact matrix

The stakeholder matrix for LH2 shows two trends among stakeholders (figure 55):

In this LH2**, the land managers** are represented solely by the landowner. This company, representing the land manager stakeholder group, shows high interest since any interventions in this LH directly affect its property and address the issues arising from site contamination.

Public bodies, civil society organizations and academia show medium high influence and interest, as mining land in disuse has become of high interest in terms of researching new ways to regenerate these areas, as well as it has increased community interest to avoid having contaminated land close to their households. Likewise, public bodies can have medium or high influence in establishing regulatory measures that could impede further degradation and impact on the communities around them.

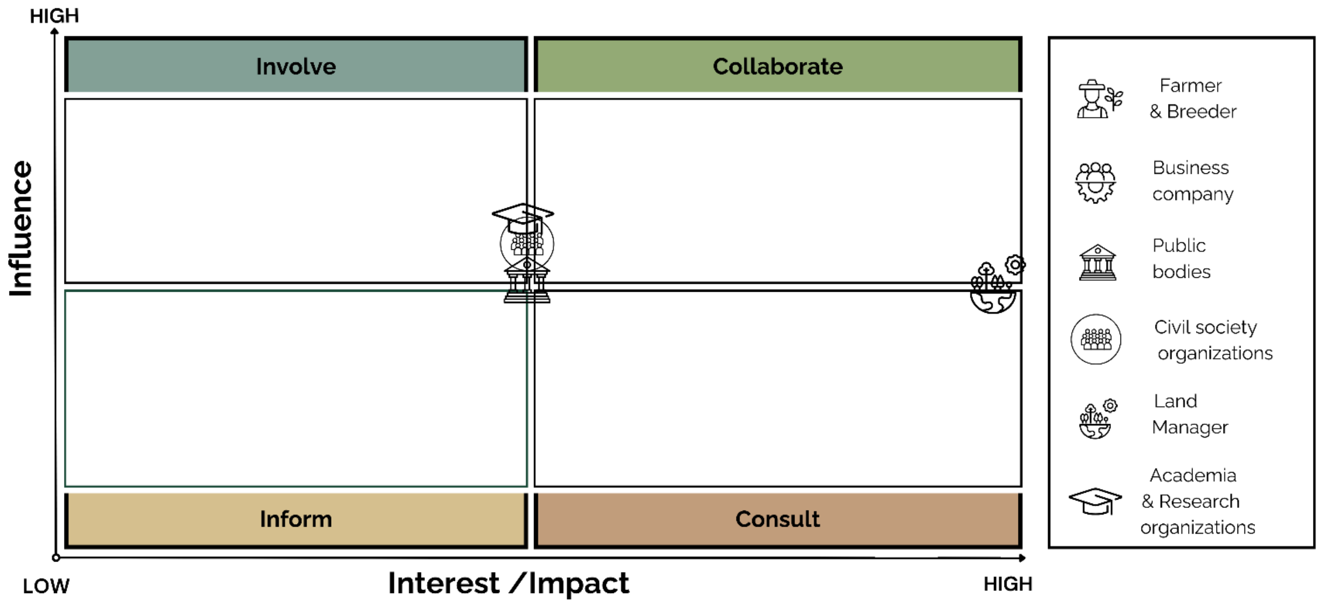


Figure 54: Stakeholder matrix of LH2.

Stakeholder map and InBestSoil co-creation activities

From the stakeholder engagement perspective, all stakeholder groups connected to LH2 are key players for Lighthouse 2. This is why, all stakeholders could be actively participating in co-creation activities in InBestSoil project, and this would improve the level of engagement with them.

The most interested stakeholder is the land manager group, in particular, the landowner of the LH2, Portman Golf.

Academia´s most important actor is already the coordinator of the LH2, and this is why it should participate actively in most activities of the co-creation plan.

Civil society organizations have been actively involved in restoring certain areas, mobilizing resources and people, and advocating for change. This is why they could participate in some activities, for example in the WP7 that is the communication part of the project, acting as a link between the local community and the project.

Nearby municipalities are responsible for ensuring that the land is managed effectively for the benefit of their citizens. Therefore, City council of La Union and the City Council of Cartagena could be allies to inform and raise awareness in the population.

LH3. Atlantic Industrial Soil – Old Touro Copper Mine

Stakeholder Distribution in LH3

Lighthouse 3 is connected to **10 stakeholders**. As shown in figure 55, these are the percentages of each stakeholder group:

- **Business Companies (40%):** This is the largest stakeholder group, and it includes four companies. One of these companies is "Centro de Valorización Ambiental del Norte, S.L (CVAN)" which is developing the remediation solution, technosol. There is also a mining company involved, called Atalaya Mining, that is willing to open the mine again to extract silver.
- **Academia (30%):** This group, composed by 3 members, includes the main university of the region, UVigo coordinator of the project, along with two other research centres.
- **Civil Society Organizations, Land Managers, and Public Bodies (10%):** Each of these stakeholder groups has one representative in the LH. In the group of civil society organizations, there is the most influential environmental organization in the area, "Ecologistas en acción". In the group of land managers, there is "Exportaciones Gallegas". Finally, in the public bodies group, we have the municipality of Touro, the local government where the industrial land is located.

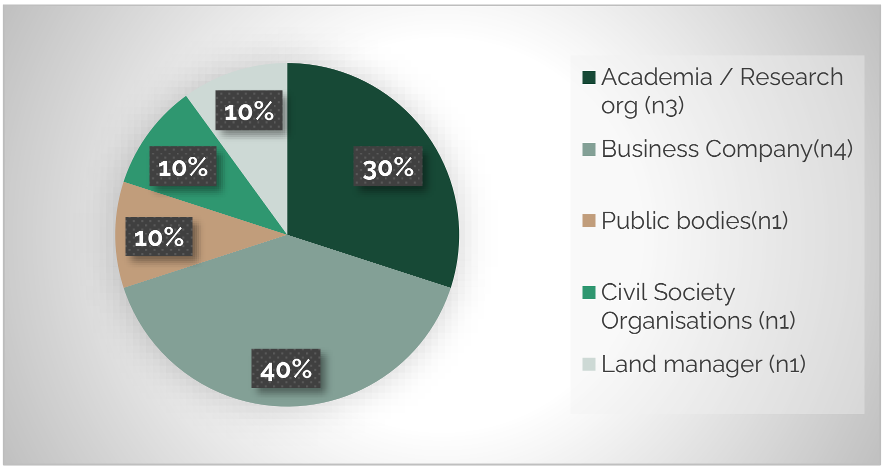


Figure 55: Stakeholder groups distribution (%) in LH3.

Stakeholder engagement impact matrix

The stakeholder matrix for Lighthouse 3 highlights three key trends among stakeholders (figure 56):

Academia and civil society organizations have low interest and influence in the lighthouse. Perhaps this is because it has been an industrial site with low access for stakeholders other than businesses. However, this type of land has become attractive to academia and researchers in terms of testing new solutions to regenerate polluted soils or impeding the reopening of the mines. This is why there might be an opportunity to increase both the interest and the influence of these stakeholder groups in the LH during the project lifetime.

Public bodies group is represented by the local municipality where the LH3 is located. This group is interested in being informed about the restoration process and the results of decontamination. They represent local community´s concerns in solving the pollution problem that affects water in the rivers nearby the old mine.

Land Managers: This group includes "Exportaciones Gallegas," the landowner of LH3. They are highly interested and influential in the development of the restoration process of LH3. They have had many issues with the pollution of the site impacting the rivers nearby, even having many problems with local populations and ecologist organizations because of that.

Business Companies: This group is also a key stakeholder in LH3. It includes one of the coordinators of LH3 and another company providing the solution for the restoration. Both companies have significant influence, as their decisions will define the outcomes of the restoration efforts in the lighthouse

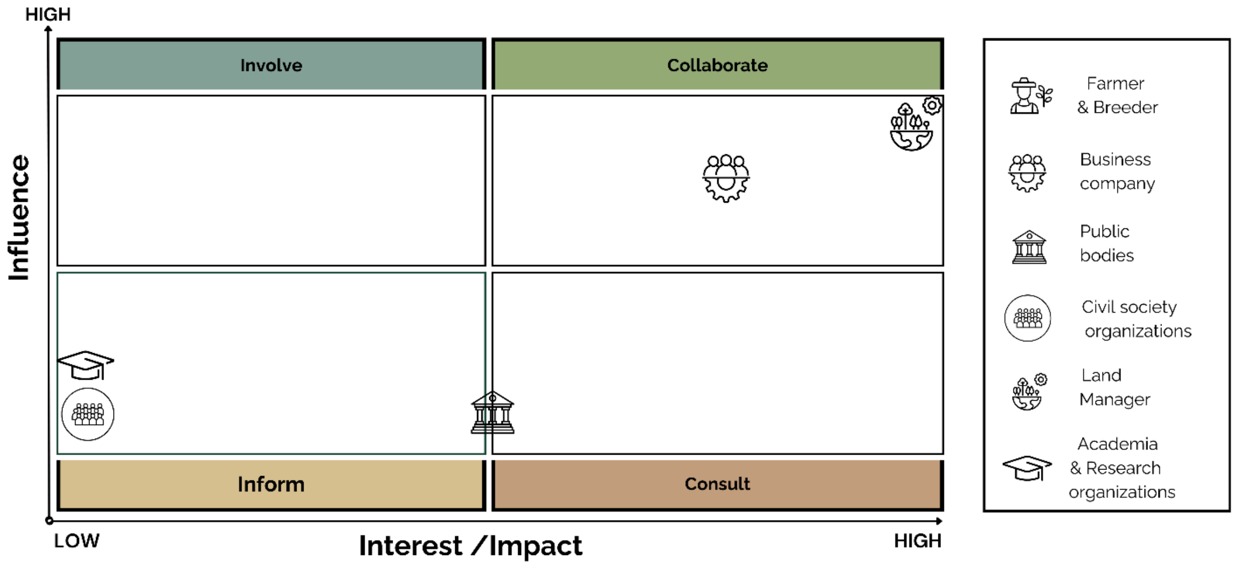


Figure 56: Stakeholder matrix of LH3.

Stakeholder map and InBestSoil co-creation activities

Business companies are crucial due to their technology, and innovations for a sustainable industrial soil management. The CVAN has a long history of collaboration with research centres, university partners, and public bodies to pilot innovative solutions using technosols to regenerate degraded and polluted mining land, so they can be an interesting stakeholder to provide input in the different co-creation activities of InBestSoil.

The land manager, as the owner of the land, holds significant influence in any projects developed in the area. Consequently, this stakeholder requires more effort to effectively engage with them. So, it is recommended to maintain regular and robust communication about project developments and LH activities. Besides, this engagement could be facilitated through the co-creation plan and the activities involving local stakeholders of the lighthouse.

For the rest of stakeholders (civil society organizations, academia & research organizations) it would be recommended to keep them informed, but with less frequency. So, it is not necessary to include them actively in the co-creation plan activities.

LH4. Continental Urban Soil – Peri-urban soils, Zagreb

Stakeholder Distribution in LH4

LH4 is connected to **32 stakeholders**. the graph (figure 57) shows the percentage of each stakeholder group, as well as the number of individual actors in each group:

- **Farmer & Breeder (38%):** There are 12 family farms connected to the lighthouse. These family farmers are potential candidates for replicating some of the business models and that is being developed in the four land uses of the LH4.
- **Public Bodies (25%):** This group includes various local and national public bodies, such as the City Office for Economy, Environmental Sustainability and Strategic Planning, and the Croatian Agency for Agriculture and Food.
- **Business Companies (19%):** It comprises different types of agricultural companies, including some that specialize in industrial processing, agricultural technology, empowerment for farmers, and climate change adaptation.
- **Academia and research organizations (12%):** institutions such as the University of Zagreb (Agriculture faculty) and Faculty of Agrobiotechnical Sciences Osijek are part of this group. They are the coordinators of the LH too.
- **Civil Society Organizations (6%):** This group represents a smaller portion of the stakeholders, but their engagement is crucial. Since, they could be useful in engaging local communities in Zagreb and supporting soil health improvement initiatives.

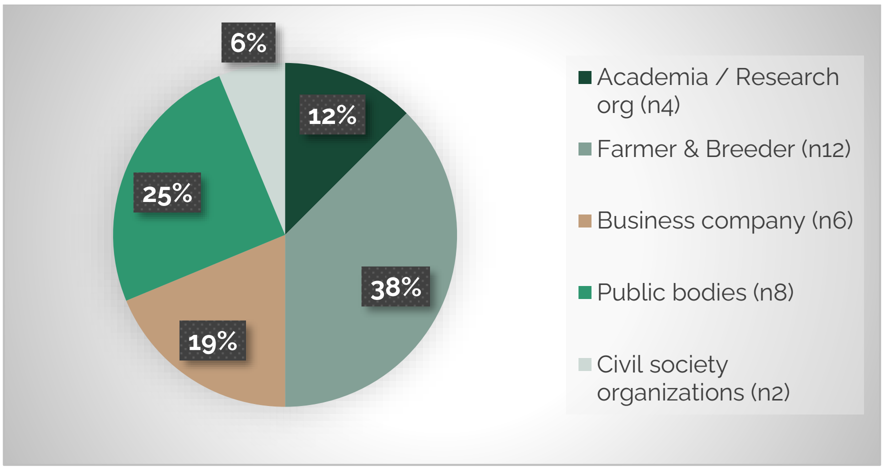


Figure 57: Stakeholder groups distribution (%) in LH4.

Stakeholder engagement impact matrix

The stakeholder matrix of the LH4 shows two main trends (figure 58):

Farmer &breeder, business company, and civil society organization show high interest in the LH4 land practises in Zagreb and InBestSoil project results, each of them for different reasons. Besides, their influence is low, since they should not affect directly the results of the LH4.

Public bodies, academia & research groups are both interested and influential, so they are both key players in this urban continental soil lighthouse. Academia´s more important players are the Faculty of Agrobiotechnical Sciences Osijek and the faculty of agriculture (university of Zagreb). Being the second one, the coordinator of the LH4. These two actors are the ones managing the lighthouse and monitoring the results. In the public bodies group, there are some actors that are more influential than others, such as the Ministry of Agriculture, responsible for spreading good agricultural practices among farmers, or the international cooperative Paying Agency for Agriculture, Fisheries and Rural Development, that is a key actor that supports farmers with different subsidies or grants. These both actors together are the responsible for applying the EU's common agricultural policy (CAP) in Croatia.

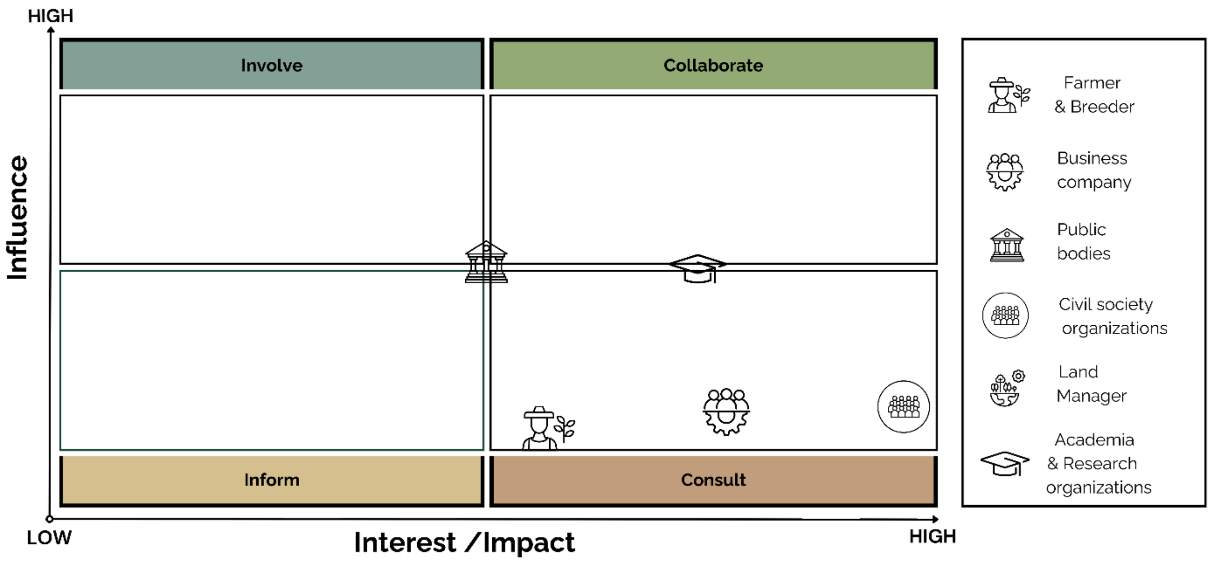


Figure 58: Stakeholder matrix of LH4.

Stakeholder map and InBestSoil co-creation activities

One of the key partners is the coordinator of the LH4, the faculty of agriculture (university of Zagreb). Since it is the coordinator, and it will normally be involved in most of the co-creation activities of InBestSoil project. It could be also interesting to include the Faculty of Agrobiotechnical Sciences Osijek and other actors in the academia group in some activities that require high level of knowledge on agronomy.

The rest of stakeholders could be included in the co-creation activities that fit the knowledge and expertise area of each group. This would help to increase the impact in the InBestSoil project and the influence of the results of LH4.

LH5. Boreal Urban Soil – Baltupiai urban gardens

Stakeholder Distribution in LH5

As shown in the graph below (figure 59), the LH5 network involves **13 stakeholders:**

- **Civil Society Organizations (31%):** This group includes one environmental NGO, a Lithuanian farmers association (that represent their farmers in the EU), the Lithuanian Agricultural Advisory Service and Association CropLife Lithuania.
- **Farmers & Breeders (31%):** This group includes four individual farmers that practice urban farming in the region of Baltupiai Gardens.
- **Public Body (31%):** This group encompasses four stakeholders, both local and national, who facilitate collaboration with relevant authorities and policymakers. Some of this are part of the Ministry of agriculture or the municipality of Vilnius.
- **Land Managers (7%):** This group includes only one stakeholder, the Forest research station Jelgava region.

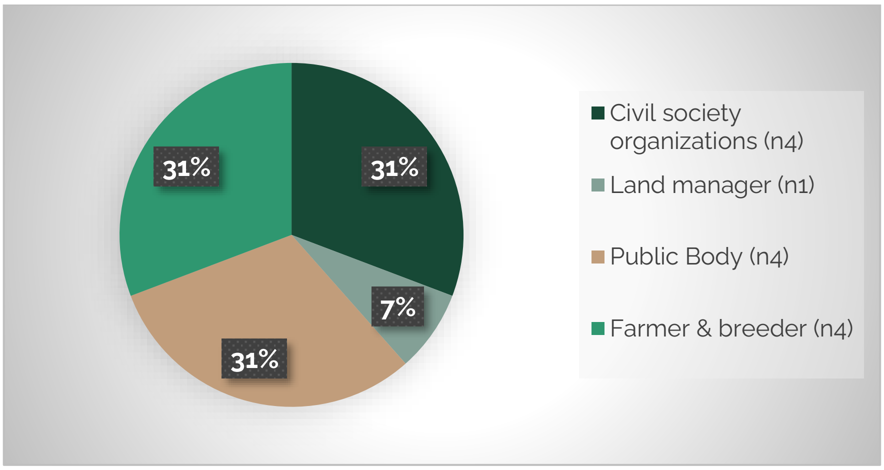


Figure 59: Stakeholder groups distribution (%) in LH5.

Stakeholder engagement impact matrix

The stakeholder matrix for LH5 reveals (figure 60) two main trends among stakeholder groups:

Farmers & breeders and civil society organizations: Both groups show interest about the InBestSoil project and the goal of LH5 of improving soil structure and tackling poor land use. This is why there is potential to engage them, keeping them well informed about the results and involving them in engagement activities.

Public bodies: This stakeholder group has a high level of influence in the LH5 and a medium-high level of interest. Within this group, the Municipality of Vilnius plays a key role in managing public land within the city, including the Baltupiai urban gardens. Additionally, the Lithuanian Ministries of Environment and Agriculture are crucial policymakers. They have the authority to enact legislative changes that can enhance soil management practices and, consequently, improve soil health.

***NOTE:** Even though the land manager group is represented in Figure 59 with one representative, it is not placed in the stakeholder matrix due to a lack of relevant information needed for proper placement.

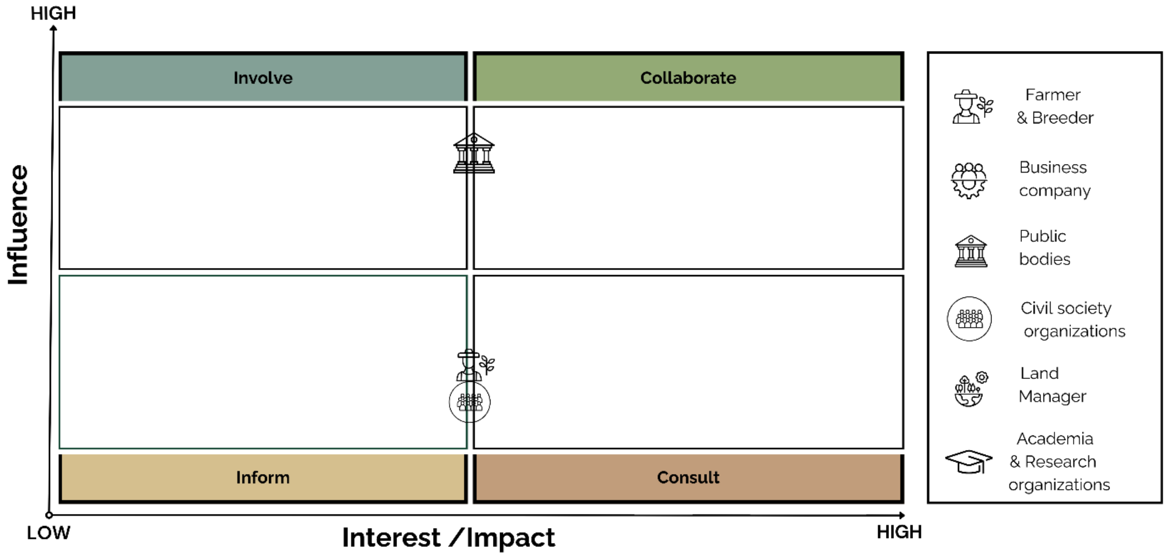


Figure 60: Stakeholder matrix of LH5.

Stakeholder map and InBestSoil co-creation activities

The primary objective of LH5 is to address issues related to poor land use in Baltupiai Gardens and to do that they would need the engagement of public and private actors. The specific characteristic of this site compared to others is the diversity of land uses (garden, grassland, park, and lawn) that is managed by different owners (public and private).

Considering this diversity and the stakeholder matrix, co-creation activities should aim for the participation of all stakeholders when relevant. Their involvement would help to include the diversity of the urban area in the InBestSoil project, and it would improve their engagement with LH5.

LH6. Boreal Forestry Soil – Mežole, Latvia

Stakeholder Distribution in LH6

LH6 is connected to **16 stakeholders.** The graph below (figure 61) illustrates the percentage distribution of each stakeholder group involved in this boreal forestry soil case study. Currently, LH6 has established contact with three specific stakeholder groups:

- **Land Managers (46%):** Land Managers, constituting 46% of the lighthouse stakeholders, are significantly engaged in the project. This group comprises a diverse range of individuals and entities (forest research stations and both public and private landowners). In the context of this experimental site, land managers hold responsibility for forest management within the land they manage or own, making decisions regarding the types of forest management practices used.
- **Public Bodies (27%)**: Four entities compose this group: Ministry of agriculture, forest owner association, state forest service and Plan protection service. These stakeholders play a crucial role in policy implementation related to forest management; additionally, the forest owner association represents the interests of landowners and provides a platform for collective action and advocacy on matters concerning forest management.
- **Academia and Research Organizations (27%):** This group has a significant representation from the University of Latvia, including four different departments. This robust connection with academic institutions highlights a strategic emphasis on research, knowledge exchange, and the integration of expertise to effectively address land management challenges.

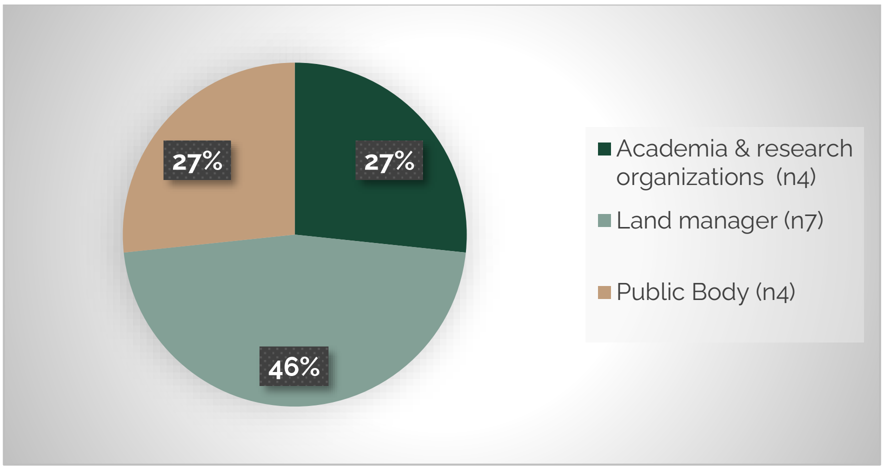


Figure 61: Stakeholder groups distribution (%) in LH6.

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Stakeholder engagement impact matrix

The stakeholder matrix for LH6 reveals two main trends (figure 62):

Academia and land manager Both stakeholder groups, academia, and land managers, are highly interested in the progress and findings of LH6, driven by their respective interest in knowledge acquisition and practical application of sustainable techniques.

Public Bodies are key stakeholders in LH6, with both high influence and high interest. Within this group, the most important actors are the Ministry of Agriculture and the Forest

Owner Association. These entities could serve as key agents of change, helping to disseminate the project's results and create a significant impact across Latvia´s forestry management approaches.

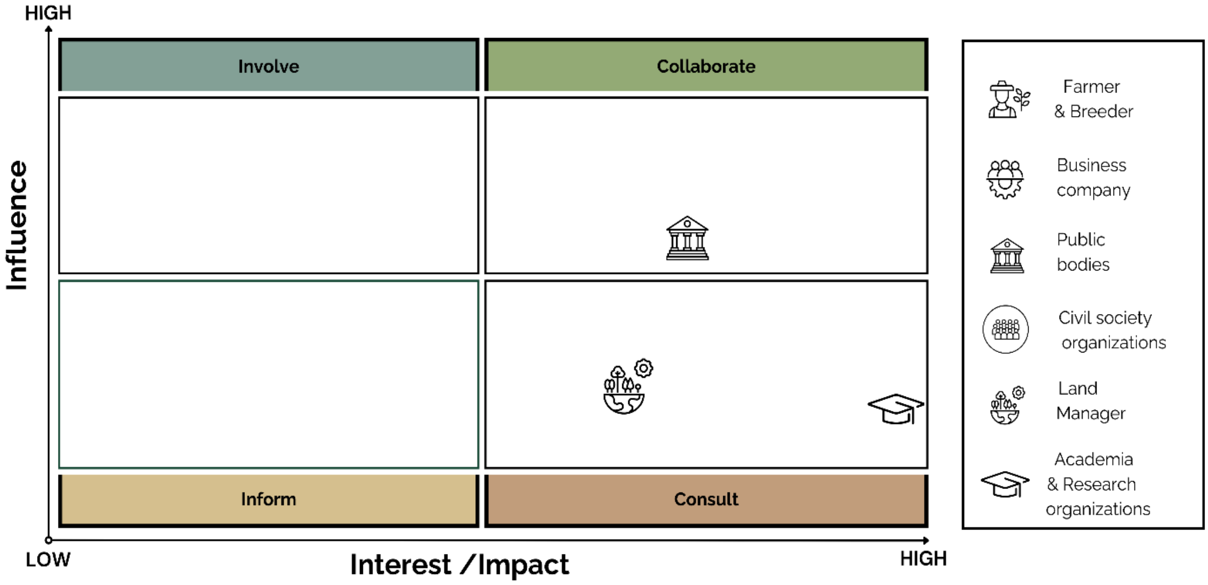

Figure 62: Stakeholder matrix of LH6.

Stakeholder map and InBestSoil co-creation activities

In LH6, maintaining engagement with all stakeholders is crucial. The co-creation plan will prioritize this, encouraging stakeholder participation in various activities, such as including them in the development of new sustainable business models (WP5).

Considering the stakeholder matrix results, public bodies emerge as key stakeholders. Therefore, it is essential to actively involve and include this group in the co-creation plan. Despite the challenges posed by time constraints, it is important to make efforts to keep this stakeholder group informed and engaged in most relevant activities.

Likewise, both land managers and academia also play vital roles. Their involvement in different co-creation activities may be more feasible and should be pursued accordingly.

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LH7. Atlantic Agricultural Soil

Stakeholder Distribution in LH7

LH7 is connected to **25 stakeholders**. The graph below (figure 63) illustrates the percentage distribution of each stakeholder group involved in this case study.:

- **Farmer & Breeder (52%):** Farmers and Breeders constitute 52% of the lighthouse stakeholders, with 13 farms currently connected to LH7. This substantial engagement with farmers highlights their critical role in contributing to the project's objectives.

- **Business Companies (20%):** There are 5 companies in this group, reflecting the importance of the private sector involvement in sustainable land management initiatives. This group includes some key companies in the area, such as Foodvalley or Agrifirm, that develops solutions for the agro-challenges in the Netherlands.

- **Academia and research organizations: (16%):** This group includes different departments of Wageningen University. This university is also involved as part of the consortium of the InBestSoil project.

- **Civil Society Organizations (8%):** This group represents a small portion of LH7 stakeholders, but their engagement is crucial. There are two members, WWF, and the Living Soil Workshop. These organizations can play a vital role in engaging the local community and supporting soil health improvement initiatives.

- **Public Bodies (4%):** This group includes one member, the public authority of Gelderland province, where the lighthouse is located.

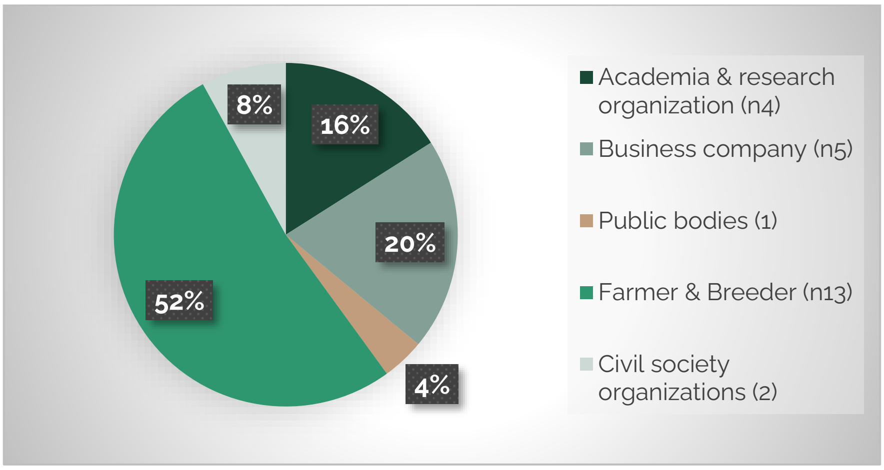

Figure 63: Stakeholder groups distribution (%) in LH7.

Stakeholder engagement impact matrix:

The stakeholder matrix for LH7 (figure 64) reveals three main trends among stakeholders:

Civil society organizations and public bodies groups have low interest and low influence in the LH7. Therefore, it seems to have a secondary role in this site. Nevertheless, it would be important to keep them well informed about LH7 activities and the results of the InBestSoil project.

Business companies, academia and research organizations have low interest but medium- high influence in this site. Consequently, it would be relevant to keep them engaged to improve their level of interest, since they have the potential to be key partners for the LH7.

The farmer and breeder stakeholder group have high interest in being connected to LH7 and learning about the innovative practices and results of the LH7. It is important to keep these farmers well-informed and address their concerns, as their strong engagement can facilitate the expansion of positive outcomes from the InBestSoil project to other farming areas.

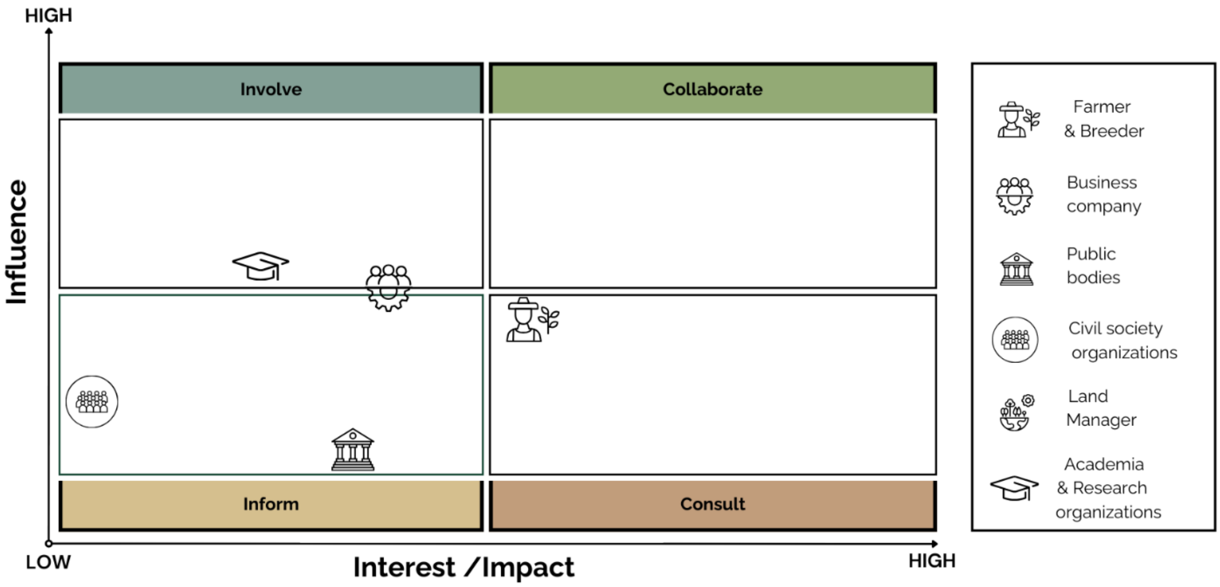

Figure 64: Stakeholder matrix of LH7.

Stakeholder map and co-creation plan

Within LH7, there exists a highly diverse matrix of stakeholders, suggesting that tailored approaches will be needed to engage them in co-creation activities:

The co-creation plan aims to engage farmers in various activities aligned with their interests and expertise, such as co-creating new sustainable business models (WP5) or developing incentive schemes (WP6). Academia brings valuable expertise and knowledge to the table, contributing significantly to co-creation efforts. While their interest may not be as high, informing business companies about InBestSoil results and inviting them to participate in selected activities of the co-creation plan can yield valuable insights and potential collaborations.

Civil Society Organizations and Public Bodies´ inclusion in co-creation activities can enhance overall engagement of these stakeholder groups in LH7. The quadruple helix model, which includes academia, industry, government, and civil society, provides a comprehensive framework for stakeholder engagement. Having such diversity of stakeholders might create an appropriate environment to establish collaboration structures such as Living Labs.

LL1. Mediterranean Agricultural Soil - Grande Pianura del Campidano, la Nurra, la Gallura and other areas of Sardegna

Stakeholder Distribution in LL1

LL1 is connected to **25 stakeholders**. The graph below (figure 65), illustrates the percentage distribution of each stakeholder group:

- **Farmers & Breeders (48%):** LL1 has established numerous connections with farmers, which aligns with the case study's objective of building relationships with the local farming community. There are in total 12 farmers connected to the living lab for the InBestSoil project.
- **Academia and Research Organizations (28%):** This group includes various departments from the University of Sassari and the National Research Council (CREA). These connections are crucial for knowledge exchange, and align with the training goals of the Living Lab.
- **Public Bodies (12%):** This group comprises entities related to agricultural and environmental practices, playing a critical role in policy support and implementation.
- **Civil society organizations (8%):** There are two entities in this group, the Nacional council of Agronomist (CONAF) and Federation and Order of Agronomist.
- **Business Companies (4%):** The LL connection in this category is with the cooperative Arborea. This cooperative is a key stakeholder in the island, since it is a cooperative that brings together 200 farmers and breeders, and it is a significant actor in the island's agricultural system.

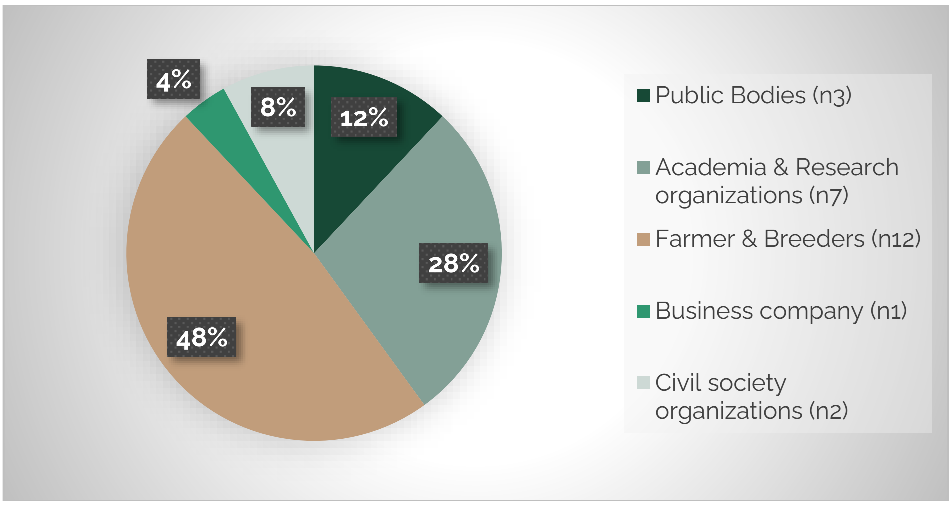

Figure 65:Stakeholder groups distribution (%) in LL1.

Stakeholder Engagement Impact Matrix

The stakeholder matrix for LL1 (Figure 66) reveals various trends among stakeholders:

Academia and Research Organizations: These stakeholders demonstrate medium influence in LL1 as they serve as the reference knowledge centres for agriculture in the region. While their interest in the project and LL1 may initially be low, increased involvement in LL1 and InBestSoil activities could enhance their engagement and interest over time.

Farmer & Breeder and Business Company: Both stakeholder groups exhibit strong interest in LL1 and the project. There is significant potential to elevate these actors to key roles in LL1 by increasing their involvement and influence in the project**.**

Public Bodies: Despite having low to medium interest in the case study, public bodies possess high influence due to their capacity to impact local policies and regulations. Therefore, it would be interesting to improve their interest in the LL1.

Civil Society Organizations: Positioned in the middle of the stakeholder matrix for LL1, civil society organizations are already in a favourable position for collaboration within the Living Lab.

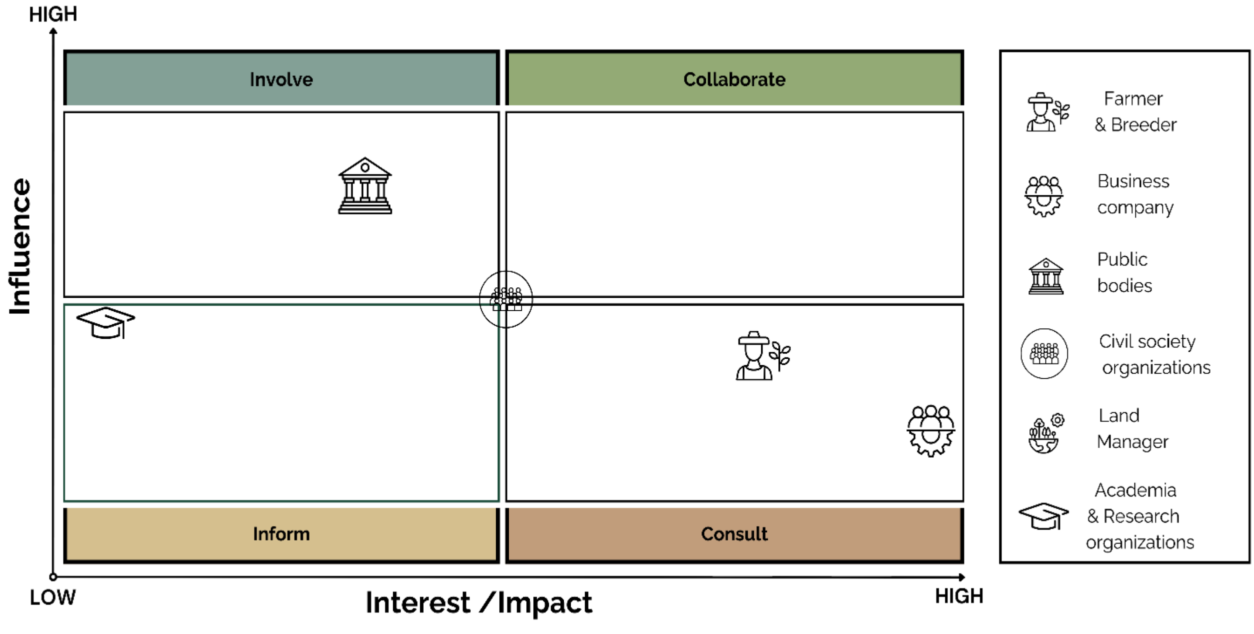

Figure 66: Stakeholder matrix of LL1.

Stakeholder map and InBestSoil co-creation activities

In a living lab setting, collaboration with all stakeholders is vital for the success of the project. Therefore, it is crucial to engage with all stakeholders in the co-creation activities of InBestSoil and foster close collaboration with them.

Civil Society Organizations in this LL1, are represented by agronomist associations that could play a crucial role in facilitating resource exchange between farmers. Farmers are almost half of the total stakeholders, and they are pivotal for exchanging good results and implementing sustainable practices on the ground. Also, Academia's involvement is essential for validating methodologies and disseminating research findings to wider audiences. Similarly, the Cooperativa Produttori Arborea, as representative of the business company stakeholder group, can serve as an ally in disseminating positive results to local farmers associated with them. Ultimately, engagement and support from public bodies can provide valuable resources and lend legitimacy to the project's initiatives.

LL2. Continental Agricultural Soil - Climate protection through humus build-up, Baselland Canton, Switzerland

Stakeholder Distribution in LL2

LL2 is connected to **15 stakeholders**. The figure 67 below illustrates the percentage distribution of each stakeholder group involved in this Continental agricultural soil area. Currently, LL2 has established contact with four specific stakeholder groups: farmers & breeders, academia, public bodies, and business companies:

- **Farmers & Breeders (53%):** This group comprises 8 farms connected to the living lab.
- **Academia (33%):** This group includes various areas within the organization FiBL, which is part of the consortium for the InBestSoil project and coordinator of LL2.
- **Public Bodies (7%):** There is one public organization connected to this case study: "Ebenrain-Zentrum für Landwirtschaft, Natur und Ernährung," the Department of Nature, Agriculture, and Food of the Canton of Basel-Landschaft.
- **Business Companies (7%):** This group includes one bank, "Basellandschaftliche Kantonalbank" (BLKB), which is collaborating in this case study with FiBL. This collaboration is developing the idea of introducing and testing impact-based credit-compensation system for the increase of soil organic matter (SOM) in the soil for farmers.

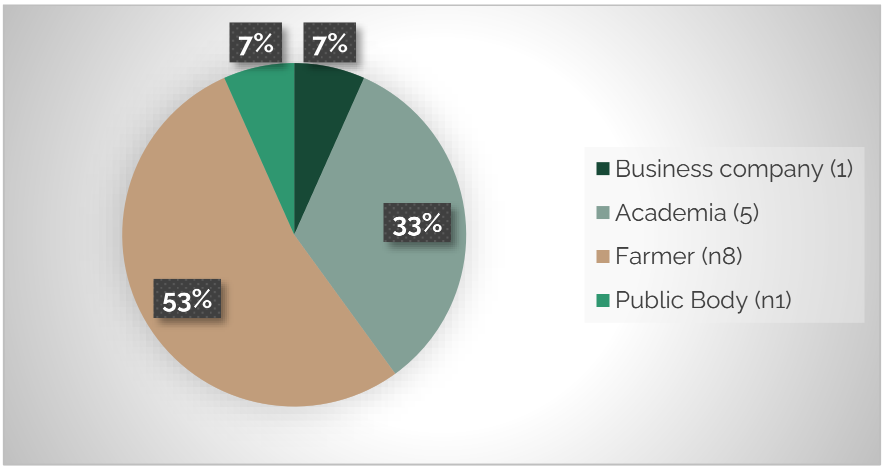

Figure 67: Stakeholder groups distribution (%) in LL2.

Stakeholder engagement impact matrix

The stakeholder matrix for LL2 (figure 68) reveals three main trends among stakeholder groups:

Farmers & Breeders and Academia & Research Organizations exhibit a high level of interest in LL2 initiatives, being both two stakeholder groups following closely the results of the project and the living lab 2.

Public Bodies, represented by Ebenrain (the cantonal department of nature, land, and agriculture), occupy a central position within the stakeholder matrix, indicating promising prospects for collaboration with LL2 endeavours.

Business Companies, with the local bank (BKLB) as a representative, are pivotal stakeholders in LL2. Their involvement is crucial as they are already engaged with LL2, introducing new business models through a regional compensation mechanism for carbon storage in soil.

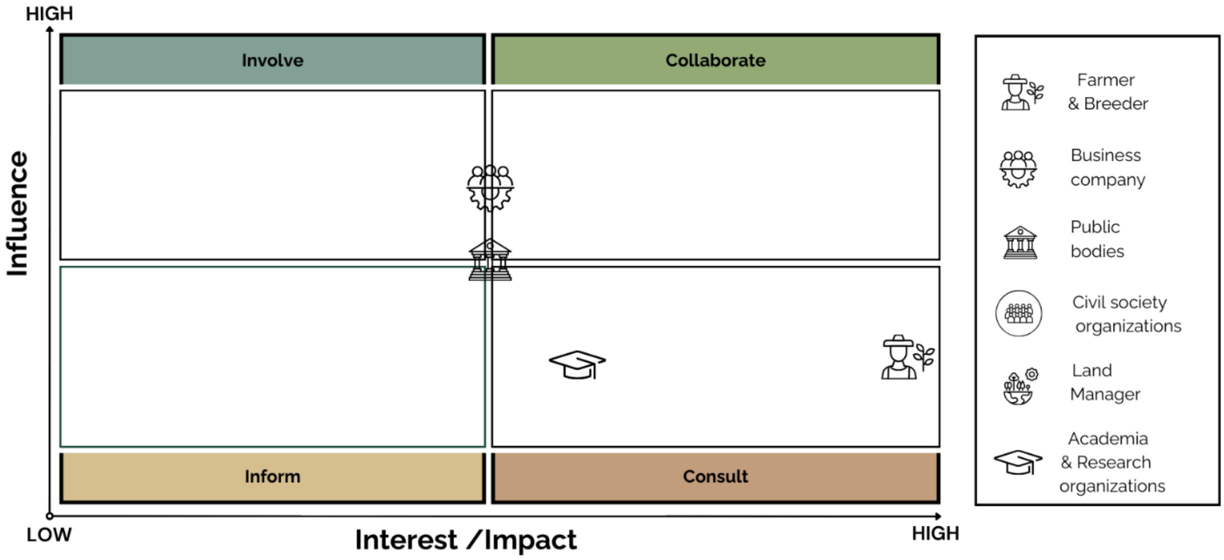

Figure 68: Stakeholder matrix of LL2.

Stakeholder map and InBestSoil co-creation plan

In essence, a living lab thrives in close collaboration with all stakeholder groups, and the co-creation activities planned within the InBestSoil project aim at leveraging this collaboration. Tailored to the expertise of stakeholders, these activities allow for varied participation across different tasks. For example, in the task related to the evaluation of carbon farming business models (WP4), a diversity of profiles such as the public entity of Ebenrain will be participating and providing perspectives that will enrich the results of the project.

While farmers and academia may not show significant influence in the matrix, their roles are key in generating and disseminating knowledge to wider spheres. As complementary groups, they are expected to engage in diverse activities outlined in the co-creation plan, alongside with being informed about project developments.

Preliminary barriers and challenges related to stakeholder engagement

There are several barriers and challenges that have been identified in relation to the stakeholder identification and mapping. These barriers have been collected in this document to be taken into consideration when progressing with project tasks:

- LH2 has been replaced. Due to management issues with the previous LH2 and as indicated during the amendment process, LH2 has been replaced by a new site. Therefore, it has been necessary to carry out the collection of information for the context building of the case and the stakeholder identification and mapping from the start with limited time available However, due to the willingness of LH2 coordinators this work was delivered in time with no major issues, although a close monitoring of the LH will be carried out in the following months in case any information needs to be updated or completed.
- Sometimes there is little to no connection between the companies involved in the case studies and other social agents that InBestSoil aims to engage with during the project. This issue has been taken into consideration when developing D2.3 Co-creation plan and the activities will be designed accordingly, with a focus to improve these connections, specially for those LH that aim at developing an LL around them.
- Regarding stakeholder mapping, the template (Table 10) is an adaptation of the initial version, which was not easily understandable in the context of soil health stakeholder mapping. This table was revised during the stakeholder identification and process, and feedback from WP5 has been incorporated for more clarity and better comprehension.
- Initially, the project site known as LH7 was designated as LL3. However, due to the characteristics of the case study, it was decided and included in the amendment to designate it a Lighthouse. Consequently, all information related to LH7 was updated to reflect its new status and role within the project.
- When carrying out engagement activities with stakeholders, it should also be considered that there are times of the year when, due to the characteristics of stakeholder groups, it might be more difficult to maintain active contact. Therefore, InBestSoil will implement co-creation activities adapted to stakeholders needs during these periods, as described in D2.3 Co-creation plan.

Conclusions

The identification of stakeholders and its mapping through the development of the stakeholder engagement matrix is a complex task due to the diversity of interpretations and perspectives that might play a role when it comes to categorise stakeholders. However, it has proved to be an interesting and valuable process for both Living Labs (LL) and Lighthouses (LH). This detailed approach and the information obtained from it forms the basis for effective engagement and communication strategies. It enhances the understanding of the various stakeholders for each LH and LL, which will help strengthening the engagement strategies withing the project, ensuring that it benefits from diverse perspectives and contributions.

The information derived from the stakeholder mapping is also valuable in determining the level of attention that each stakeholder group requires when designing the activities in which they will participate. This assessment takes into account their interest in participating and their influence: by strategically prioritising stakeholders based on these criteria, we can ensure more effective and targeted participation, optimising the overall results of the activities.

There is a growing consensus on which stakeholder groups are essential within the EU Mission "A Soil Deal for Europe". Accordingly, this deliverable has taken into account the categorisation agreed during the Mission Soil project clustering discussions. By aligning InBestSoil´s stakeholder identification and engagement strategies with this agreed categorisation, we ensure that our efforts are focused on the most relevant and impactful groups for the mission, thus improving the overall effectiveness and alignment of the project with it.

From the initial stakeholder identification (a list with a total of 213 stakeholders), six distinct stakeholder groups were identified: Business Company, Land manager, Farmer/Breeder, Public Bodies and Civil Society Organizations. The number of potential stakeholders vary significantly across case studies; this information could also give us an insight into which LH have more potential to become LL (T2.4). This deliverable identifies the different levels of engagement required for the various actors connected to each LL/LH, and it provides and overview of the amount of information and commitment needed to keep them involved in the project.

For instance, certain key stakeholders were recognized as needing special attention and strong engagement:

- **LH1:** Both Fundación Global Nature and ACTYVA Cooperative Society have effectively engaged with numerous stakeholders in the area. The stakeholder matrix for LH1 identifies farmers & breeders, civil society organizations, public bodies, and academia as highly relevant and potentially influential, being key stakeholders for consultation and participation in co-creation activities. The business company stakeholder group shows lower interest but remains important to keep informed and engaged. This is an LH considered to have potential to build an LL around them (T2.4)

- **LH2:** The University of Cartagena collaborates with landowners in this area, It will be important to maintain this collaboration and involve other key stakeholder groups to be actively participate in co-creation activities in InBestSoil project to improve the level of engagement with them.

- **LH3:** CVAN's history of collaborating with research centres, universities, and public bodies makes them valuable for input in InBestSoil's co-creation activities. Land managers, as landowners, have significant influence and require regular, robust communication and engagement.

- **LH4:** Farmers & breeders, business companies, and civil society organizations show high interest but low influence in LH4 practices and InBestSoil results. Public bodies, academia, and research groups are both highly interested and influential, making them key players. The University of Zagreb as the coordinator of this LH will be the link between stakeholders in the area and the project.

- **LH5:** Farmers & breeders and civil society organizations show interest in the project and its goals, indicating potential for engagement. Public bodies, particularly the Municipality of Vilnius and the Lithuanian Ministries of Environment and Agriculture, have high influence and medium-high interest in this LH, making them crucial for legislative changes and soil management practices so maintaining them informed and interested in project activities would be helpful for Mikolo Romerio University as coordinators of this LH.

- **LH6:** SILAVA coordinates this LH where academia and land managers are highly interested in due to their focus on knowledge and sustainable techniques. Public bodies, including the Ministry of Agriculture and the Forest Owner Association, are key stakeholders with high influence and interest too, being capable of disseminating project results and impacting Latvia's forestry management.

- **LH7:** The Ekoboerderij de Lingehof (EKO) farm has already engaged a good network of collaborators and stakeholders around them. Farmers & breeders have high interest in the activity of LH7 and should be kept well-informed and invited to participate in project activities. Civil society organizations and public bodies show lower interest and influence, but still needing to be kept informed and invited to participate in co-creation activities and project initiatives when relevant. Business companies, academia, and research organizations have low interest but medium-high influence, requiring attention to try to boost their interest in LH7.

- **LL1:** This LL is coordinated by Agris and CMCC who have a long history of collaboration with local stakeholders. This is why farmers, breeders and business companies present strong interest in the LL. Academia and research organizations demonstrate medium interest which suggest that focusing on specific points of interest for these groups could enhance their involvement over time. . Public bodies, despite moderate interest, wield high influence over local policies, making them a key stakeholder group to maintain informed about project activities and progress in the area.

- **LL2:** Farmers & breeders and academia & research organizations show significant interest in LL2 initiatives which are based on long lasting relationships cultivated by FiBL over the years. Public Bodies, hold a central position in the matrix, suggesting strong potential for collaboration with LL2 activities. Business companies play a pivotal role, actively participating in the introduction of new business models like regional carbon storage compensation mechanisms for soil.

The results of D2.2 Identification and mapping of stakeholders will be used during the project lifetime to ensure that the project co-creation activities (D2.3) respond to real needs and contexts for each LH and LL and therefore, these could be adapted accordingly.

Annex I

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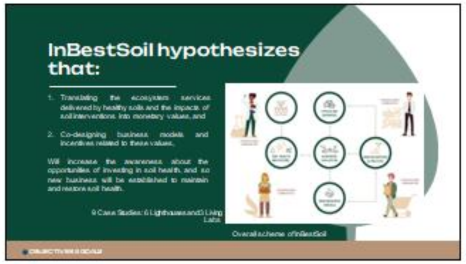

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