PREPSOIL DELIVERABLE

Title	Synthesizing soil needs and drivers of change across Europe and land use types
Work package no:	WP2
Deliverable Related no:	D2.1
Deliverable no:	7
Deliverable description:	The deliverable contains the Soil Needs Assessment (SNA), a methodology to assess soil needs in a geographical area. The SNA is applied to 20 case studies across Europe and the results are synthesised.
Due date:	31.10.2023
Submission date:	21.12.2023
Dissemination level:	PU DOI 10.18174/651649; CC BY 4.0
Authors:	Bayer, Lukas; Bandru, Keerthi; Chowdhury, Shaswati; Gómez, Pablo; Sanchez, Ivan; Nougues, Laura; Jordan; Sabine; Maring, Linda; Barron, Jennie Keesstra, Saskia; Helming, Katharina
Version:	V1.0

Project acronym: **Project name:**	**PREPSOIL** **Preparing for the 'Soil Deal for Europe' Mission**
Project number:	**101070045**
Call topic:	**HORIZON-MISS-2021-SOIL-01-01**
Type of action:	**HORIZON-CSA**

Funded by the European Union

Contributors

Name	Organisation & Country
Bayer, Lukas; Bandru, Keerthi; Chowdhury, Shaswati; Helming; Katharina	ZALF, Germany
Gomez, Pablo; Sanchez, Ivan	CSIC - INIA, Spain
Nougues, Laura; Maring, Linda	DELTARES, Netherlands
Jordan, Sabine; Barron, Jennie	SLU, Sweden
Keesstra, Saskia	WR, Netherlands
Halberg, Niels	AU, Denmark
Individual authors in Annexures of case studies	Various

Revision history

Version	Date	Reviewer,	Modifications
0.1	4.10.2023	Bayer, Lukas; Bandru, Keerthi;	First draft
0.2	10.10.2023	Helming, Katharina (ZALF, Land Use Coordinator)	Comments on first draft
0.2	17.10.2023	Keesstra, Saskia; Gomez, Pablo; Sanchez, Ivan; Nougues, Laura; Maring, Linda; Jordan, Sabine; Halberg, Niels	Review and comments on first draft
0.3	14.11.2023	Bayer, Lukas; Bandru, Keerthi	Second draft
0.4	11.12.2023	Halberg, Niels; Sanchez, Ivan; Nougues, Laura; Jordan, Sabine	Review and comments on second draft
1.0	20.12.2023	Bayer, Lukas; Bandru, Keerthi; Helming, Katharina.	Final version

Table of content

List of Abbreviations

C	Carbon
CAP	Common Agricultural Policy
CO_2	Carbon Dioxide
DPSIR	Driver-Pressure-State-Impact-Response
EEA	European Environmental Agency
EU	European Union
LCA	Life Cycle Assessment
LLs	Living Labs
MS	member states
NUTS	Nomenclature of Territorial Units for Statistics
PDO	Protected Designation of Origin
RDP	Rural Development Plan
SMS	Soil Mission Support
SNA	Soil Needs Assessment
SOC	Soil Organic Carbon
UN	United Nations

List of Figures

List of Tables

1 Executive Summary

Life on Earth depends on healthy soils. Soil is the foundation of food systems. It provides clean water and habitats for biodiversity while contributing to climate resilience. It supports cultural heritage and landscapes and is the basis of economy and prosperity. Although we take soils for granted, they are a scarce, threatened resource. It is estimated that between 60 and 70% of European soils are unhealthy. Indeed, one centimetre of soil can take thousands of years to form but can be lost in just a single rainstorm or industrial accident.

Subject to geophysical and biochemical conditions, climate, past and current land uses, soil properties and (ecosystem) services exhibit high spatial variations. Assessing the needs of soils to maintain and improve soil health requires a regional approach that also considers emerging drivers, challenges and opportunities.

The European Union's Soil Mission implementation plan lists eight soil health objectives ranging from geobiophysical soil properties to soil literacy in society and to reducing the global soil footprint. To achieve these objectives, the PREPSOIL project is supporting the implementation of the Soil Mission by creating awareness and knowledge on soil needs among stakeholders in regions across Europe and land use categories (agriculture, forest and natural, urban, and post-industrial). Within the project, as a first step towards developing a long-term collaboration with stakeholders in a living lab context, an assessment of soil needs in 20 representative European regions was conducted (Figure 2-1).

The novelty of the soil needs assessment approach is a systems research perspective on soils, focusing on the functioning of social systems and their impacts on soil health and ecosystem services. Consequently, the systems approach helps us understand the drivers for soil health and supports the identification of emerging opportunities for their improvement. In furtherance of understanding the societal needs from healthy soils and soil needs from societal actors, it intends to describe the complex interaction between society and the soil ecosystem.

> "**Soil Needs** are defined as the requirements from existing and emerging socio-economic and geo-biophysical perspectives that determine soil health and related services to human society." (Helming & Bayer 2023)

The soil needs assessment (SNA) was constructed as an interdisciplinary and participatory research approach that combines natural science knowledge on the functioning of soils and ecosystem services with research methods from social sciences. Expert knowledge and literature analyses were combined with participatory methods to collect stakeholder perspectives as well as to generate awareness and literacy on the importance of soils. The research was conducted along the five categories of the Driver-Pressure-State-Impact-Response (DPSIR) framework (Figure 2-2). The framework categorises human-environmental system interactions in addressing external drivers for decision making on land use and soil management, respective effects on soil health, ecosystem services impacts and options for soil improving response measures. Such system interactions are subject to regional variations, therefore 20 representative regions across Europe were selected. Our focus was to reflect the diversity of European land use types, socio-economic and geo-biophysical conditions of soils. Hence, we consider systems in agricultural production, forestry, urban and (post)industrial, and mixed land uses.

More than 500 stakeholders representing farmers, policy, government, advisors, research, business, civil society organisations and non-profit government organisations interacted during the participatory research process (Figure 4-2). Results were presented and discussed at the European Mission Soil Week in Madrid (21-23 November 2023; https://www.europeanmissionsoilweek2023.com/en/event-material) with a plenary presentation, a break-out session focussing on different land use types, and with 20 posters (1 for each region) displayed throughout the week and compiled in a booklet that was disseminated at the event. Feedback received during the week further informed the interpretation and synthesis of results as well as the key recommendation provided below. This deliverable reports on the soil needs assessment across regions and land use types. Results are synthesised for each land use type to allow identification of commonalities but also specificities. Comprehensive, individual reports of each of the 20 regional assessments are provided with annex. The booklet of posters (https://prepsoil.eu/sites/default/files/2023-12/PREPSOIL%20Booklet%20Soil%20Needs%20Workshops.pdf) provides a summary and entry point of the results presented in this deliverable.

Key Recommendations derived from the soil needs assessments:

- Soils needs must be taken into consideration when land use decisions are made at all levels starting from regional to national and European.
- Policies and economic incentives for farmers, foresters, land users and city developers should target the provision of soil-based ecosystem services alongside business activities to meet societal demand from soils.
- Soil sealing for housing, industry and infrastructure purposes needs to be minimized especially in rural areas, while de-sealing of land should be implemented where possible.
- Limiting land abandonment with a clear renaturing plan and monitoring process is necessary to avoid harmful consequences (erosion, pests etc.,) of land abandonment.
- Forest management and restoration activities should focus on mitigating climate change impacts (avoid diebacks, control pests, and release of greenhouse gases).
- Agricultural production should consider multifunctionality of soils thereby balancing production with the provision of ecosystem services and biodiversity.
- Multiple income sources in rural areas should be generated and incentivized to avoid overexploitation of soil resources on one side and land abandonment following outmigration on the other side.
- The implementation of living labs may be an opportunity to co-develop soil health solutions but need to be equipped from bottom up and financed at long term.
- The soil needs assessment approach reported here may be adopted in other European regions through EU Soil Mission projects.

2 Introduction

In the Anthropocene, humans continued the transformation of land through the expansion of cities, industrial production, and the use of natural resources to feed and house a growing population. Global land degradation had reached one hundred million hectares per year between 2015 and 2019, having severe effects on food and water security. The global estimates of the soil loss during that period are equivalent to twice the size of Greenland. Worldwide drivers such as urban expansion, deforestation, and grassland conversion, in combination with global warming, continue to degrade land with greater forcing (United Nations 2023).

The land humans use consists of a complex soil ecosystem, on which human society vitally depends. Soils provide various functions, that we use as ecosystem services. In agricultural and forest systems, these include biomass production, water storage and filtering, biodiversity habitat, soil organic carbon storage, and nutrient cycling. In urban land uses, humans use soils as the space for human activity, such as housing, traffic infrastructure, manufacturing, and industrial areas, but also for water absorption and storage, cooling through evaporation, growing trees for cover against heat, and green spaces for recreation and mental health (Duranton and Puga 2015). In an urban context, their functions and ecosystem services are often severely limited compared with more natural land uses. Maintaining these functions is an interest that must concern all of humanity. Their partial loss will result in ecosystem breakdown from the bottom up. Activities undertaken by societies in the European Union have led the states of the soil to a point of degradation, which has not been observed before (EEA 2020; Tesfai et al. 2015).

Research activities on soils have historically been restricted to their disciplines and exchange has been rare, taking a natural science focus on specific aspects of soils' physical, chemical, or biological properties and processes, or taking a production-oriented focus on agronomy, forestry, or infrastructure/urban development. A systemic research perspective on the multifunctionality of soils and the ecosystem services they provide is only emerging. Especially research on the system's complexity of interactions between human activities and their management of soils and land is yet underdeveloped (Löbmann 2021; Keesstra et al. 2016; Visser et al. 2019). One key objective of the Mission Soil is the establishment of 100 Living Labs as vehicles for systems wide, regionally based, participatory research and innovation for healthier management of soils.

The here reported approach is a *Soil Needs Assessment* which is interdisciplinary and participatory. We combine both natural science knowledge on the functioning of soils and ecosystem services (Constanza 1998; Paul et al. 2020) with research methods from the social sciences (Mayring & Fenzl 2019; Moon & Blackman 2014; Vaccaro et al. 2010; Yin 2018). We combine expert knowledge and literature analysis with participatory approaches in the form of workshops to elicit knowledge and to generate awareness and literacy on the importance of soils. The social science activities centre around a workshop series and structured interviews with stakeholders to validate or question the assumptions on soil physical problems, attitudes towards management techniques, and their understanding of the functioning of the socio-economic system. The focus of our analysis are the interactions of human activities and their underlying cause, and the impacts activities have on soil ecosystems as well as the current benefits provided by the soil ecosystem to humans (Zare et al. 2019; Turner et al. 2016) A detailed overview of the methodology is provided Annexure 2.

The soil needs assessment used the five categories of the Driver-Pressure-State-Impact-Response (DPSIR) framework (EEA 1999). The framework allowed us to analyse the systems´ interactions between human activities and the natural environment. A system, we understand as "a collection of parts that interact in a meaningful, inseparable way to the function as a whole" (Ford 2019). This definition is applied to the soil ecosystem and the human socio-cultural-economic system. The following two definitions are developed to define the operating space of this analysis:

- **Soils Health:** the continued capacity of soils to support ecosystem services, assessed through a set of proposed, measurable indicators (Implementation plan, p. 5, (SWD (2021) 323 final, p. 5))
- **Soil Needs**: the requirements from existing and emerging socio-economic and geo-biophysical perspectives that determine soil health and related services to human society (own definition).

This allowed the analysis to formulate the needs for soils not in the intrinsic sense for their own ecosystem wholesomeness, but for the *needs soils have in order to provide ecosystem services to the human system, as an inseparable link, as long as either exists.*

In this regard soil needs are:

- *Drivers* that improve soil health management.
- Precautionary soil management *pressures*.
- *States* that, when combined, form healthy soils.
- *Impacts* that are beneficial to ecosystems and humans.
- *Responses* that protect soils or limit ecosystem service decline.

The soil needs were assessed according to the DPSIR framework in 20 exemplary regions across Europe. We used a study design of a most different case study approach (Yin 2018). The focus was to present cases to reflect the diversity of European land use types, socio-economic and geobiophysical conditions for soils. Therefore, we considered various agricultural production systems, forestry systems, urban and (post)industrial systems, and mixed land use systems.

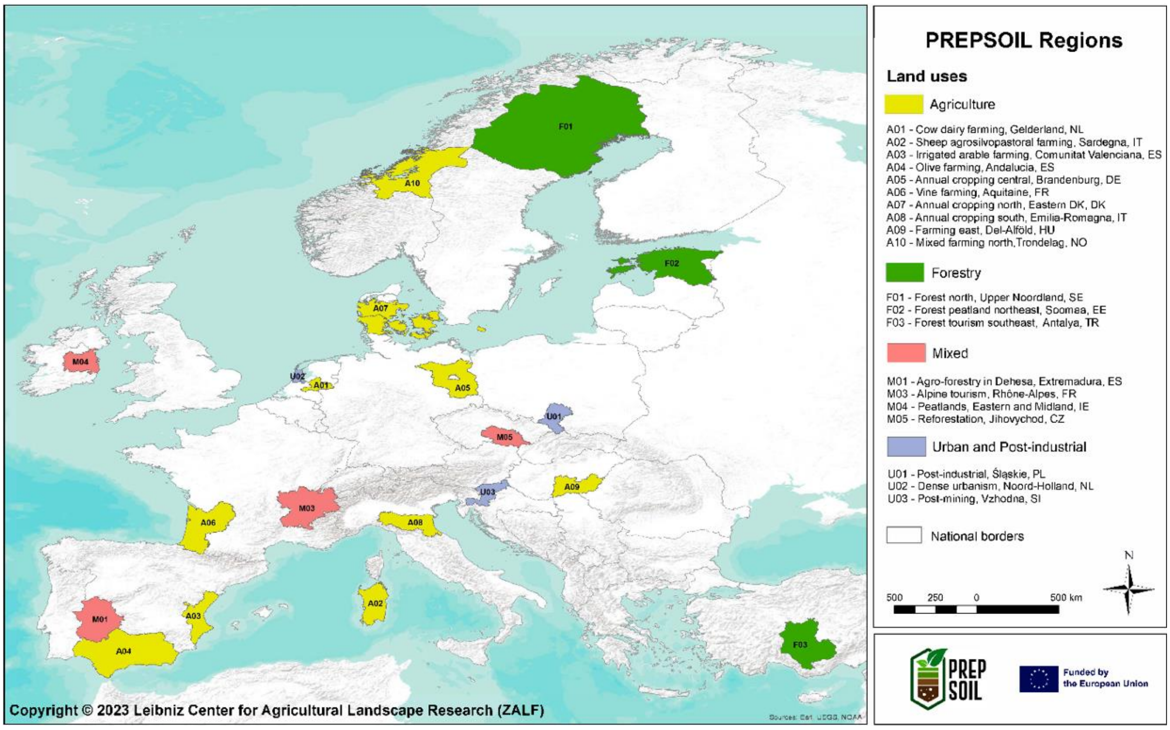


Figure 2-1: Selected regions for the soil needs assessment.

The deliverable is structured as follows: Chapter 3 provides the methodology with a brief description of the approach to the case study selection, and the methodological details in the case studies. Chapter 4 is a synthesis of the case study findings, structured alongside the major land use types. Here, key elements of soil needs are synthesized for each land use type despite the acknowledgement of the regional diversity of Drivers, Pressures, States, Impacts, and Responses regarding soil health. Annexures 1 and 7 provide the regional briefs with each case details. Annexure 3-5 provides the research guidelines, interview questions and reporting templates that were used by the partners.

2.1 Conceptual Framework for the PREPSOIL Soil Needs Assessment

The main synthesis framework follows the DPSIR approach, a functional framework for structuring the cause-effect relationships of human-environment interactions (EEA 1999; Helming et al. 2018; Schjonning et al. 2015). In Figure 2-2 we adapted the DPSIR framework for the PREPSOIL SNA approach, redefining each category for our intended use. The framework conceptualizes complex sustainability challenges and provides insights into the relationships between the environment and human beings (Hamidov et al. 2018, following Gabrielsen &

Bosch 2003; Brils 2008). Applying the framework allows for adaptability to various impact areas, objectives, and scales (Tscherning et al. 2012).

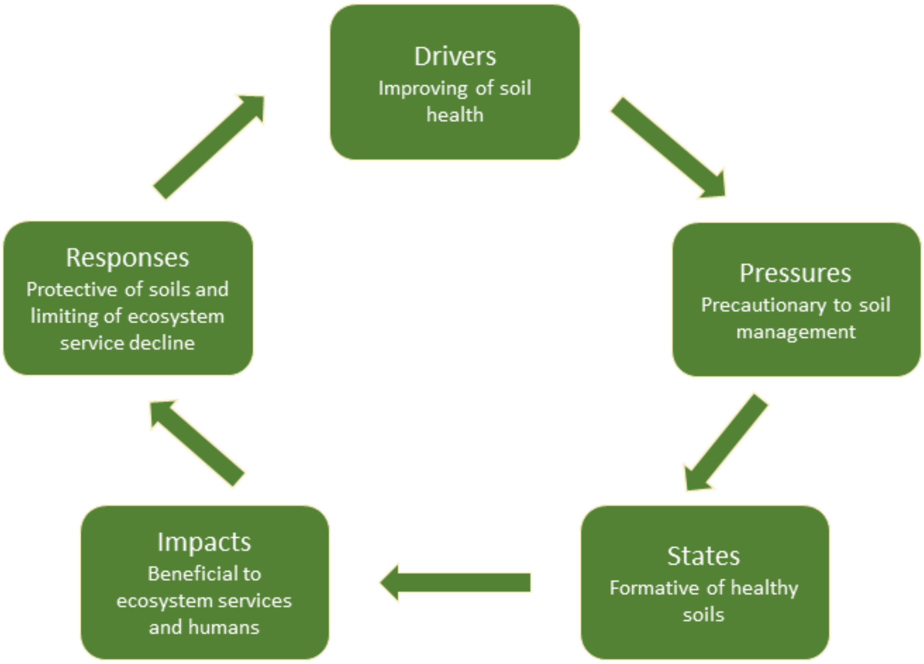


Figure 2-2: Driver-Pressure-States-Impacts-Response Framework used in PREPSOIL.

Driving forces include anthropogenic developments (economic, societal, and cultural) such as technology development, tourism, demographic changes, related demand and consumption, values, governance, and policy. Aside from societal drivers, environmental changes such as climate change and its effects (droughts, floods, diseases, etc.) are considered drivers. These drivers lead to **pressures** (positive or negative) on the natural environment. In relation to soil, these include soil use and management practices. Such pressures are the physical perturbations being exerted on the ecosystem. The pressures may change the **state** (state variables, processes) of these ecosystems in quantity and quality. The states refer to soil properties, processes, and quality characteristics, including levels of erosion, compaction, contamination, water retention capacity, and all soil functions. The **impact** of such soil state changes refers to the (ecosystem) services that the soil supports. This includes biodiversity, resilience to floods and landslides, water quality and availability, biomass provision for food, feed, and energy. Several **response** measures (policy, research, societal action (e.g. in LLs), changed land use and management practices) may be tried to avoid degradation and even restore the soil functions in order to improve the provision of ecosystem services. A systemic approach to soil health requires consideration and understanding at each of the DPSIR levels but more than their individual categories, how they interact with each other (Ford 2009).

3 Methodology

The research followed an embedded *multiple case research design* (Yin 2018). In this research approach, multiple contexts: *land uses*, are researched simultaneously, while each context has various internal cases (Figure 3-1). Within each case we applied one unit of analysis: using the DPSIR Framework and following the developed PREPSOIL research guidelines (Annexures 3 - 5). The design allows for variation in difference, considering the four predefined land use types (agriculture, forest, and nature, mixed, and urban and (post)-mining/industrial). Similarly, the complexity of urban land use requires a delineation from a post-mining context which can be found in the regional briefs (Annexures 1).

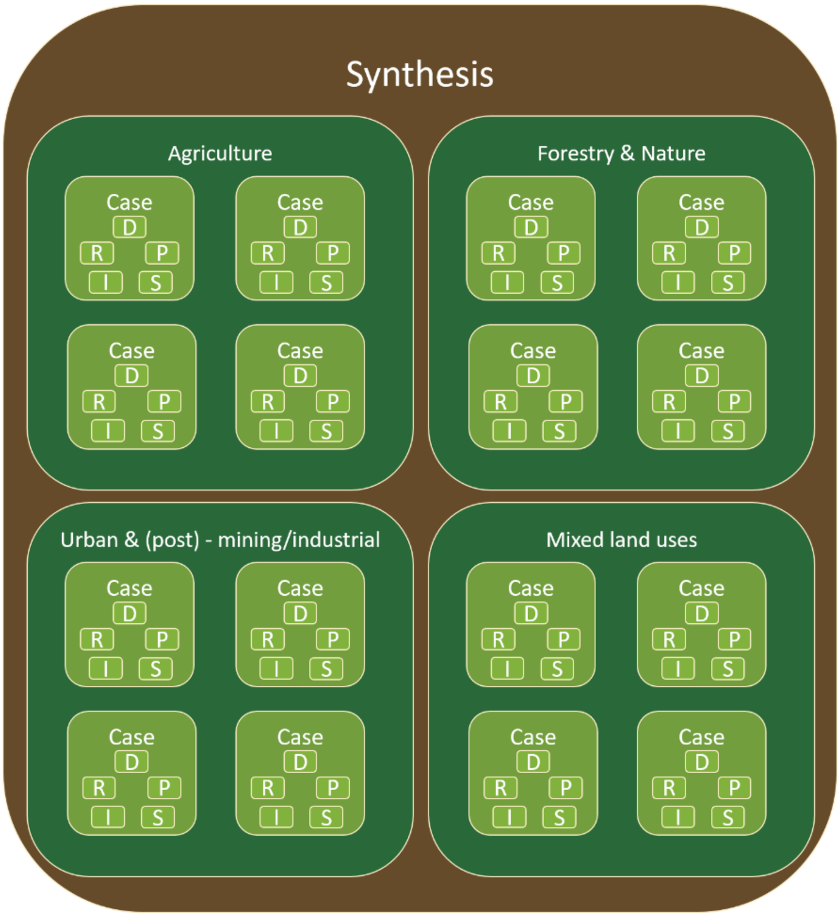


Figure 3-1: PREPSOIL multiple embedded case study research design (adapted from Yin 2018)

The conceptual level was further elaborated by three stages of methodological considerations as described in the Figure 3-2: (1) define and design; (2) prepare and collect; and (3) analyse and conclude (Yin et al. 2018). In the first define and design stage, we used the DPSIR framework on a conceptual level to design a data collection protocol and to design a workshop and expert discussion rounds to select cases for our analysis. The selection required some variation from ideal-type case selection, as practical considerations such as the availability of resources and representation of PREPSOIL partners in regions in Europe needed to be taken into consideration.

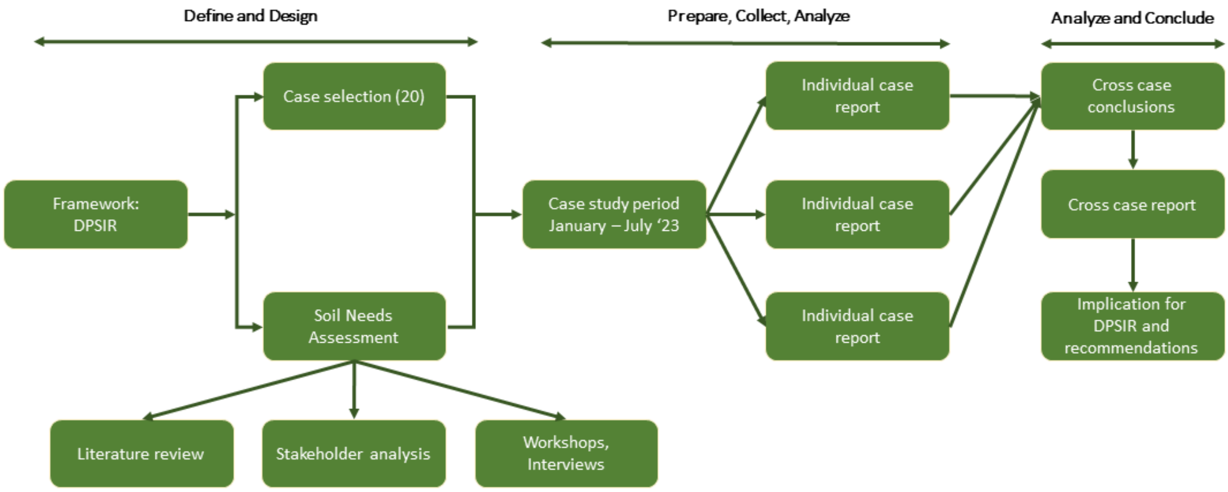


Figure 3-2:Multiple case study research design steps in PREPSOIL

The second phase of Prepare, Collect, Analyse followed the methodological guidelines provided (Annexure 3). The individual case reports are attached in the form of regional briefs and represent a summary of the original case reports. The third phase, Analyse and Conclude, followed a coding exercise in Excel. Here, we combined a textual qualitative content analysis (Mayring & Fenzl 2019) with an abductive approach by using the reports of case studies to generate new insights into the DPSIR framework as our theoretical search heuristic (Timmermans & Tavory 2012). Nonetheless, the methodological challenges through the need of categorisation to communicate any abstraction of land uses, did not affect the results of the individual case study reports as the DPSIR framework provided a conceptual framework, flexible enough to accommodate all contexts.

3.1 Selection of Regional Cases in Europe

The objective of the PREPSOIL regional soil needs assessment is to apply the methodology to twenty regions which would represent European regions in terms of soil, climate, geographical location as well as, socio-economic conditions, and land management system. A selected region needed to be experiencing soil health problems but also includes at least one site serving as a lighthouse where sustainable management (from both a biophysical and socio-economic point of view) is planned or is already in place. Thus, for each provisional region participants with expert knowledge drafted a first tentative list of "soil threats." which would be evaluated as part of the case-study (Table 3-2). Each region also needed to representative of other regions in Europe for most Europeans to recognize their own living environment in one of the PREPSOIL regions.

The selection process followed an iterative process consisting of three simultaneous workshops during the kick-off meeting (Aarhus, September 2022) of the project. Participants were asked to focus on a specific land use and were divided into three discussion groups according to their knowledge (agriculture, forest, and urban/industrial). Within each workshop group, participants were asked to identify potential representative regions for their target land use based on the agreed land use types (Table 3-1). We used the EU NUTS2 regions as guidelines as the delineation is used by socio-economic criteria and often by administrative level. However, within the NUTS2 regions, specific problems were analysed on landscape level, depending if the problem was specific to the entire NUTS area or on a landscape level. Nonetheless, the administrative responsibility of the landscape remains on NUTS 2. The results of the workshops at the kick-off meeting were refined in expert discussion groups (participants from within the project partners of WP2) to come to a balanced set of regions for the different land use categories. The selection and discussion were supported by information available at the NUTS2 level. Finally, we selected 20 regions, of which 10 have a dominant agricultural land use, 3 have a forest or natural land use, and 3 have an urban or (post-)industrial land use. In addition, we selected four regions where there was not one dominant land use but two or more co-existing land uses (e.g., agroforestry) or where a fast land use change is taking place (e.g., land abandonment). The share of 50% of the cases having agriculture as dominant land use resembles the share of agriculture on the land area in Europe. Practical considerations were also considered, such as the location and network of PREPSOIL project partners, their existing knowledge, and existing stakeholder networks and living labs. To make sure to have a balanced selection, we organized the topics of interest as representative regions in a triangular space (Figure 3-3).

Table 3-1:Land use types agreed in the PREPSOIL project.

Land use Type	Sub-types				
Agriculture	non-perennial cropland	Perennial cropland	grassland	mixed	agroforestry
Forestry	Forest on mineral soils	Forest on organic soils			
Natural	(semi-)natural drylands	(semi-)natural peatlands			
Urban	urban	peri-urban			
Industry	industrial	post-industrial	mining	post-mining	
Mixed	All combinations				

Elements that were included in the selection: Soil type and climatic zones: organic and mineral soils in the European temperate climate, soils in the Mediterranean climate with semi-arid hot spots, marine west coast climate, and humid continental climate. Based on literature analysis and expert knowledge, all 20 regions were categorized by climatic zone, WRB soil classification, dominant soil type, dominant topsoil texture, environmental zones and most relevant soil threats (Table 3-2). The identification of most relevant soil health objectives in each region (table 4-2) resulted from the further literature analysis and participatory research.

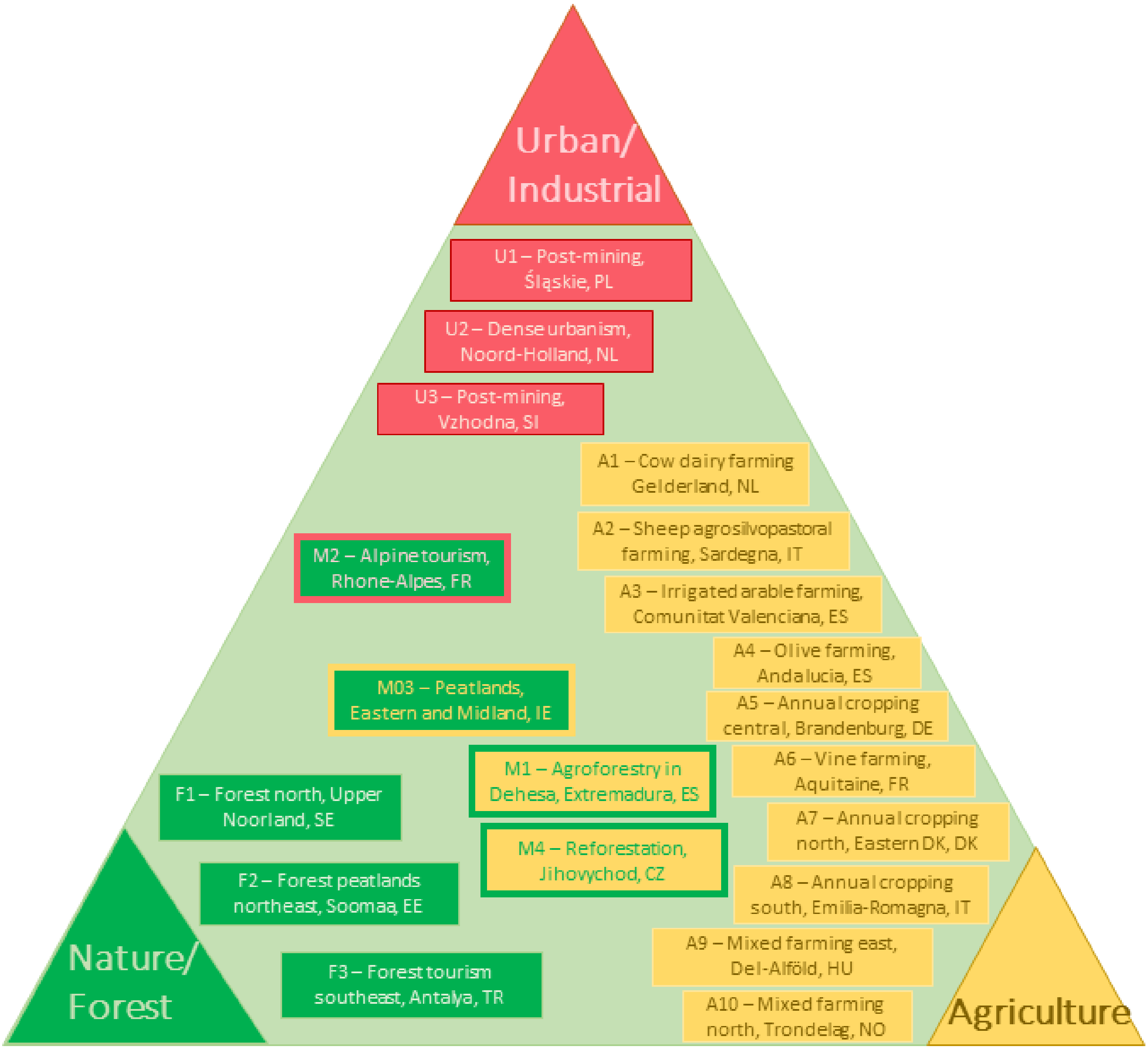


Figure 3-3:Representation of the types of dominant land use found in different regions. Including: agricultural (yellow), urban/industrial (red), forestry or nature (green) and mixed land use (multi-colour)

The specific land use systems covered per land use are:

- Agriculture: different farming systems, including organic, irrigated agriculture, conservation agriculture, regenerative agriculture, high-input agriculture, precision farming, and agroecology.
- Forest and nature areas: production forest and natural ecosystems on mineral and peat soils, and wetlands/peatlands.
- Urban and (post-)industrial areas: pure urban, post-industrial, and post-mining, as well as areas where human pressure (soil sealing and pollution) is interfering with other land uses (nature and agriculture).
- Mixed zones: challenges in performing the transition to more sustainable agricultural practices due to changing and multiple co-existing land-use activities, tourism, reforestation, and land abandonment.

Table 3-2: Information of the selected regions across Europe

Case	A01: Cow dairy farming, Gelderland, NL	A02: Sheep agrosilvopastoral farming, Sardegna, IT	A03: Irrigated arable farming, Comunitat Valenciana, ES	A04: Olive farming, Andalucia, ES	A05: Annual cropping central, Brandenburg, DE	A06: Vine farming, Aquitaine, FR
Soil threats	Too dry (Podzol, Anthrosol), Too wet (Fluvisol), Soil compaction (everywhere)	Water erosion, desertification, land abandonment, forest fire	Soil erosion, soil pollution.	Water Erosion, desertification, salinization, pollution, compaction.	SOC decline, compaction, biodiversity decline, soil erosion (water, wind, tillage); decreasing water retention capacities	artificialisation, erosion, compaction, pesticide and copper pollution, loss of biodiversity
Dominant land use	Dairy farming	Agroforestry sheep farming	Irrigated agriculture, adjacent drylands cropping	Agriculture, Olive farming, tree cultivation (predominantly traditional rain-fed cultivation). 78% of the agricultural surface in this region (ES616) is dedicated to olive groves.	Annual cropping	wine growing, cereals, grassland, fodder
Secondary land use	Arable farming	Mediterranean maquis, permanent pastures, urban	Peri-urban and nature. Rangelands and forest of Pinus halepensis.	Natural/forestry, urban (rural).	Forestry: metropolitan region Berlin is spreading into Brandenburg	Urban and peri-urban
Climatic zone	Temperate oceanic climate	Mediterranean, with 3 months drought in Summer and rainfall in Autumn and Spring	Mediterranean with a 3-month drought in Summer and rainfall in Autumn and Spring	Mediterranean: mean annual T from seven °C -18 °C and a mean annual precipitation of 400–570 mm with occasional summer droughts.	continental	Oceanic
Soil WRB classification	Podzol, Fluvisol Anthrosol"	Rock outcrop, lithic xerorthents, secondly xerochrepts, typic, dystric, lithic xerorthents etypic, dystric, lithic xerochrepts, secondly palexeralfs haploxeralfs	Aridisoles and Entisoles	Mainly cambisol and regosol.	Luvisols	Cambisols, Gleysols, Luvisols, Podzols
Soil type	Podzol Fluvisol Anthrosol	From sub-acid to acid soils	Soils on calcareous silts with low carbon content.	Carbonated materials (marls, limestones and dolostones). High calcium carbonate content and high pH (6-8). Low nutrients content.	dominantly loamy sand, sandy loam; 4% organic soils	Sandy loam, silt-clay, graves
Dominant topsoil texture	"Sand (in the higher regions) Clay (in the valleys) "	Mainly from sandy to sandy-argillaceous soils	loamy clays and sandy clays (depending on geology type)	Mainly coarse texture and high stone content. Loam to clay in some areas.	Loamy sand and sandy loam	Sandy loam, silt-clay, graves
Environmental Zone (Metzger et al. 2005)"	Atlantic North	Mediterranean South and North	Mediterranean South and North	Mediterranean South, North and Mountains	Continental	Lusitanian
Representative regions	Fladers, Northwest Germany and Denmark, regions where intensive agriculture close to Natura2000 areas	Agrosilvopastoral in whole Mediterranean area	Irrigated agricultural areas across the Mediterranean (in Italy, Greece, Slovenia, Cyprus, France, Turkey, Croatia, Malta, Albania)	Andalusia, Castilla la Mancha, Extremadura, Peloponnese, Crete, Ionian Islands, Apulia, Calabria, Molise, Cyprus, other olive-growing regions (Italy, Greece, Cyprus, Croatia, etc.).	Po Valley, Veneto, Emilia-Romagna, Lombardy, and Normandy, Regions in Eastern Europe.	Vineyards characterized by oceanic climate, large production of Merlot. This vineyard offers variety of terroir and soil types, vineyard regions in France, Spain, Italy.

Case	A07: Annual cropping north, Eastern DK, DK	A08: Annual cropping south, Emilia-Romagna, IT	A09: Organic mixed farming east, Del-Alföld, HU	A10: Mixed farming north, Trondelag, NO	F1: Forest north, Upper Norrland, SE	F2: Forest peatland northeast, Soomaa, EE
Soil Threats	Soil organic carbon loss, nutrient loss, compaction (topsoil and subsoil), water erosion, reduced water retention capacity, reduced soil fertility.	Soil sealing; soil organic matter loss; drought; flood; soil erosion; soil pollution; soil salinity; functional soil biodiversity deterioration	Wind erosion and desertification due to climate change and historical change in water management.	High precipitation, poor drainage, soil compaction (saturated soil during harvest), soil erosion, soil sealing. Part time farming, intensive agriculture, limited time on farm work, lacking/to small economic incentives, high pressure on agricultural land.	Climate change, Droughts and extreme weather, bark beetle outbreaks, browning of freshwater, Soil damage and compaction; ditching affecting soil health, carbon sequestration and storage below and above. ground, and biodiver-sity	Peatland drainage for forestry; tracks from harvesters
Dominant land use	Agriculture	Agriculture: croplands	Cropland, Field crop production	Production forest	Forest (87 %): Scots pine (Pinus sylvestris L., 63 %) and Norway spruce (Picea abies (L.) H. Karst., 26 %) mixed with deciduous trees (Betula spp., Alnus incana (L.) Moench., and Populus tremula L., 11%)	Forestry on fens and transitional peatlands, and on the edges of the bogs
Secondary land use	Urban	Urban/ industrial	Grassland with extensive livestock farming, fruit and vine	Agriculture of 61% gras production, 27% cereals, 11 % grasland (for grazing), 1,2 % potato and vegetable, 0,1 % berries and fruit production	Mires (9 %), lakes (1 %), agricultural lands (2 %), and rock outcrops (1 %)	Nature protection (bog area with pools, forest habitats, semi-natural meadows, and birds)
Climatic zone	Atlantic North, Continental	Temperate Subcontinental	IPPC climatic zone: Warm Temperate Dry	Alpine north / atlantic north	cold temperate, humid, mean annual precipitation of 638 ± 40 mm, mean annual air T of 2.4 ± 0.3°C	Temperate
Soil WRB classification	Luvisols, Cambisols, Regosols	Cambisols	Arenosols, Cambisols	Stagnosol (dominant WRB), Gleysol, Cambisol, Arenosol, Histosol, Podzol, Leptosol, Regosol, Phaeozem, Fluvisol, Planosol, Umbrisol	Podsols, Regosols, Histosols, Gleysols, Leptosols and Arenosols	Histosols, Gleysols, Fluvisols, Histic gleysols, Gleyic albeluvisols
Soil type	Post-glacial moraine	alluvial soil	Quicksand, humus sand	Agricultural soil	Podsols, Regosols, peat soils, Gleysols, Leptosols and Arenosols	Peat soils (bogs and fens)
Dominant topsoil texture	Loams, sandy loams and sandy clay loams	Variable texture, medium to fine, with a high fraction of alterable minerals and carbonates.	Sand, loamy sand	Silty loam/clay loam	Silt, sand, fibric and decomposed peat	Highly decomposed peat
Environmental Zone (Metzger et al. 2005)	Atlantic North, Continental	Mediterranean North and Mountains	Continental, Pannonian	Alpine north	Boreal	Atalantic central, Boreal
Representative regions	Annual cropping as dominant land use, e.g. Scania (Sweden), Southern Finland, Northern Germany, Northern France, Poland.	(blank)	Sandy part of Szabolcs-Szatmár Bereg (HU), regions in sandy soils suffering droughts	Cereal production and mixed farming at high latitudes.	Fennoscandia, Baltics	Forestry on peat soils mainly in Scandinavia and Baltic states (Northern Europe)

Case	F3: Forest tourism southeast, Antalya, TR	M1: Agroforestry in Dehesa, Extremadura, ES	M2: Alpine tourism, Rhône-Alpes, FR	M3: Peatlands, Eastern and Midland, IE	M4: Reforestation, Jihovychod, CZ	U1: Post-mining, Slaskie, PL	U2: Dense urbanism, Noord NL	U3: Post-minig, Vzhodna Sloveni-ja, SI
Soil Threats	Water erosion, lime accumulations, poor topsoil, soil degradation, low organic matter,	Erosion, compaction, lack of fertility	Climate change (erosion, changes in the cryosphere and water, increase in climatic hazards and risks in the high mountains, increase and elevation of wooded areas, artificialization of valley bottoms, greening), Mass tourism (urbanization, biodiversity degradation)	Drainage of peatlands led to peat shrinkage, compaction, subsidence, erosion and greenhouse gas emissions	Erosion, Acidification	contamination, sealing, land abandonment	Sealing, contamination, loss of biodiversity, loss of organic matter (peat), land subsidence, soil degradation due to disturbance, compaction, and -in parts (external)-salinization (through Noordzeekanaal)	Soil erosion, Soil contamination, Soil acidification, Urban sprawl and urbanization, Invasive organisms
Dominant land use	Protected area + ExtensiveTourism & Recreation	Extensive grazing	Natural, agriculture (pastoral)	Agriculture, forestry	Agriculture land 61 %.	industry	Artificial land	Forest
Secondary land use	Forestry, semi natural areas, Agriculture (Rural)	Self-consumption agriculture	Recreative (skiing, biking, etc.)	Previously energy peat production	Woodland 30%.	urban/arable	Artificial built-up area (industrial, sealed), Infrastructure, parks and gardens, urban agriculture, recreational areas	Grassland
Climatic zone	Mediterranean climate (Csa) with hot and dry summers	Mediterranean	Mountain climate / continental	Temperate	Moderate Continental	IPCC - cool temperate moist	Moderate maritime (or oceanic) climate	Temperate oceanic climate, without dry season and warm summer
Soil WRB classification	1-Order: Entisol, Sub-order: Orthent, 2-Order: Alfisol, Sub-order: Xeralfs, 3-Order: Inceptisol, Sub-order: Xerepts	Leptosol, Cambisol and Regosol	Cambisol, Colluvic Regosols, Hyperskeletic Leptosols	Histosols	Dystric Cambisol, Gleyic Luvisol.	Cambisols, Luvisols, Podsols	Gleysols and Histosols (but mainly technosols)	Cambisols: Eutric, Dytric or Chromic , Leptosols: Mollic, Rendzic or Dystric
Soil type	Terra Rosa	Shallow, sandy loam textured, slightly acidic and relatively poor in nutrients	Limestone, silt, acid and calcareous stones / glaciers	Peat	Medium	NA	Anthroposols, peat, sea clay	Cambisols, Leptosols
Dominant topsoil texture	Clay Loam	Sandy-loam	Limestone	Peat; often highly decomposed peat	Medium.	Silt loam, sandy loam	NA	Different Loamy textures (loam, silt loam)
Environmental zone (Metzger et al. 2005)	Mediterranean Mountains	Mediterranean South	Continental	Atlantic Central	Continental	Continental	Atlantic Central	Alpine south, Continental
Representative regions	Forest areas in mediterranean climate, hot summers, susceptible to wildfires.	Extremadura, Northern Andalusia, Western Castilla-La Mancha, Salamanca, and Ávila (Spain), Alentejo, Algarve (Portugal)	Alpine massive	Midlands Northwest Region	Jihlava	post-industrial areas in Eastern Europe	Highly urbanized areas all over Europe. Especially in same climatic regions / delta areas (soft soils).	Post-mining region, Central European region

3.2 Methods for data gathering

The participatory approach used for acquiring the knowledge necessary to fill the DPSIR conceptual framework was a series of workshops and interviews. The implementing researcher decided the precise design of each workshop, due to the differences in regional settings and previous knowledge available to the researchers. The basis for the knowledge was a thorough literature review and a desk analysis, which can be found in each regional briefs in the Annexures 1 and 2. The workshops served as a way of validating the knowledge acquired from the desk analysis and gathering identified gaps in knowledge. Also, the workshops were designed in a way to consider future developments. The understanding of the framework and the coherence of the assessment were facilitated during two internal project workshops on December 16 and 19 of 2022. All necessary steps were taken into consideration to harmonise the methods across the regions and respect the GDPR guidelines of the stakeholders.

3.3 Workshops

The workshops in all the regions followed a predefined agenda, which was adapted by the local partners. Due to the multitude of partners, the regional adaptation of the detailed process during the workshop day varied to match with local needs and knowledge basis. An overview of the workshops and their agendas can be found here: https://prepsoil.eu/. The general focus points of the workshops were to elicit stakeholder perspectives on soil needs defined through the DPSIR framework.

3.4 Interviews

The intention of conducting stakeholder interviews was to fill knowledge gaps in SNA and the data unknown to researchers. The extent of interviews conducted depended on the researcher's previous knowledge, access to stakeholders, and necessity to gather more data. A template with example questions was provided to partners (Annexure 5). Researchers were instructed to document their interview data, which were then translated into reporting template (Annexure 5).

3.5 Data Analysis

Researchers went into the research context with a pre-conceptualized heuristic and were looking at the object of study through the lens of the DPSIR concepts. The sense-making of the reality in the region and the need to better understand the needs of soils were accordingly focused on the needs as defined. We relied on previous work (Helming 2018) to give a specific categorization for the DPSIR framework, relying on the work of the natural sciences in understanding the natural processes in soils. When new specificities in the DPSIR categories emerged, we noted them and provided them as further subcategories of, e.g., a new driver that occurs in a specific context and regional case (modify theory or concept). The case could then be substantiated further if, e.g., the driver also occurred in a second region, etc (refer Figure 3-2 for additional information). The analysis was conducted for each case individually and synthesised across for land uses.

3.6 Validation of Results

The synthesis results were initially shared among the PREPSOIL WP 2 leaders and the regional representaitves. The feedback from the partners was included in the synthesis. In the next step, the results of the synthesis were discussed and validated in the European Soil Week, 21-23 November 2023 (https://www.europeanmissionsoilweek2023.com/en). The project leaders presented the methods and results at the plenary that followed by the breakout session where the regional leaders presented their results to wider audience. The feedback from the participants were taken into consideration in the revisions. This additional validation design assisted to capture the policy relevance and core inputs from the other mission projects to align the future activities (see Annexure 6).

4 Synthesis of Results

The SNA in the European regions was conducted by the PREPSOIL project, which set out to analyse the existing and emerging socio-economic and geo-biophysical conditions that determine the health of soils as indicated by their ability to provide ecosystem services. The synthesis of the information provided in the DPSIR framework of the regions, and the land use type allows to draw some general conclusions on the functioning of the socio-economic systems.

The combination of scientific review of literature and other a priori knowledge from the case areas with stakeholder input succeeded in populating the different stages of the DPSIR framework. Overall, this demonstrated the degree to which soil needs are impacted by multiple factors across the land use and socio-economic systems and how -across a wide range of European regions – high level driving forces determine soil management and thereby impact soil health and subsequently eco-systems services through the adaptation by land users to socio-economic conditions and technological developments. The assessment is meant to provide a basis for the future identification and co-development of responses to these developments. Such a process is intended to take place in the living labs, which are to be implemented through the soil mission programme. The response options provided in this report reflect initial and partly generic proposals for technical and/or political solutions derived during the regional assessments.

Overall, the DPSIR-approach demonstrated that in all regions Soil Needs should be determined across systems levels. Thus, in a combination of requirements for specific – innovative - land management practices taking into account local geo-biophysical conditions and emerging drivers such as climate change as well as requirements for the larger societal level from value chain actors to policy makers. This again points to the need for a R&I based development approach which may integrate different stakeholders and interdependencies across different systems levels. It needs to be stressed that the innovation capacity does not only lie in the development of novel technologies but also and especially in social innovation and changes in the social system (e.g., behavior of society). The basic idea of the Mission Soil, establishing Living Labs across Europe seems in this light well conceived.

While the cause-and-effect linkages of the DPSIR framework are traceable in the regional case studies, the level of abstraction required for the synthesis for different land use types poses as a challenge. Synthesis results presented here are therefore seen as an introduction to the individual case results. Nonetheless, the introduction of a systems approach to multiple land uses, linking socio-economic systems to the soil ecosystem has been proven to be successful in deriving a systemic understanding of cause effect relationships during the participatory assessment processes. Future research should consider a system dynamics approach, where the formulation of the problem lies at the centre of the first stage. An integration into the context of living labs seems feasible considering the methodological similarities of input from stakeholders into the problem definition setting and the following scientific discussion on the pre-defined issue (Sterman 2000; Vennix & Gubbels 1992; Zare et al. 2019).

The regional bio geophysical conditions are relevant to the analysis but are considered to be unique to the region and too context-specific to be generalizable. They are therefore found in the state and impact sections of each case study report. The specific regional socio-economic and bio geophysical circumstances are also presented in the individual case studies (see Annexes 1 and 2). Similarly, to the uniqueness of drivers are the soil mission objectives (Figure 4-2) which clearly shows how each regions has multiple soil health objectives to address. The overall synthesis provided here takes a focus on the drivers and pressures, showing interactions between categories, and describing how drivers reinforce or limit negative or positive pressures for soil health.

Synthesis across land use types and regions:

Soil needs:

a) In agricultural land uses we find that decision-making is strongly driven by previous decisions (path dependence) and by the Common Agricultural Policy (CAP) formalizing the path in a direction of uniformization, simplification and standardization of agricultural management. Local site conditions are not sufficiently considered, which in combination with unsystemic, external input-based management methods lead to soil health deterioration. Despite the implementation of soil improving agri-environmental measures under the CAP pillar II scheme in many European regions, CAP pillar I subsidies give impulses for favouring the production function of soil on the costs of the other soil functions. Transforming CAP to a balanced payment for ecosystem services scheme would better recognize the fundamental role, agricultural soil management has for maintaining ecosystem services including climate change mitigation. Such a policy transformation would level the playing field for all actors involved in the production and increase ecosystem services for the population in the region.
b) In forest land uses where the focus is on a managed forest with a high turnover of planted forest, decision-making needs to take sustainable forest management strategies into consideration to maintain and improve soil health. The reliance on monocultures is no longer feasible in the face of climate change, as pests (bark beetle outbreaks) will occur more frequently in coniferous monocultural production systems. A sudden dieback of large parts of boreal forest could release substantial amounts of CO_2 previously captured in the soils of northern forests. Policy ambitions need to take the

governance of forests as a common pool resource into consideration. Emerging eco-tourism in regions may further trigger diversification of forest stands.

c) In mixed production systems, most prevailing in marginal areas, planning and decision-making need to take into consideration several aspects and overlapping policy frameworks. Like agricultural and forest land uses, governance approaches should include and create long-standing institutions for the joint management of mixed land uses. Therein, participation should be a regular approach and management decisions are taken jointly to prevent soil health degradation.

d) In urban and agglomeration systems, the consideration of soil health and the ecosystem services they provide would necessitate fundamentally different decision-making processes. The sealing of soils and the respective detrimental impacts would need to be integrated into the decision-making process at the policy level through environmental policy integration (in the form of soil policy integration). Additionally, the re-use of invested energy and resources in the built-up environment would need to be considered first before the construction of new buildings. The change would have far-reaching consequences for the urban sprawl of villages in rural areas.

The here described soil needs ought to be considered in combination with the regional variation of the soil mission in Figure 4-1. The table clearly shows on the one hand the great regional variance occurring in the soil missions' objectives. The overlap of the multiple soil health objectives shows how various threats exist under each land use simultaneously. Especially noteworthy is that desertification processes and the loss of soil biodiversity occur currently in most regions independent from the land use type.

Land Use Category	Region/Soil Mission Objectives	1. Reduce desertification	2. Conserve soil organic carbon stocks	3. Stop soil sealing and increase re-use of urban soils	4. Reduce soil pollution and enhance restoration	5. Prevent erosion	6. Improve soil structure to enhance soil biodiversity	7. Reduce the EU global footprint on soils	8. Improve soil literacy in society
Agriculture	A01: Cow Dairy Farming			■	■	■	■		
	A02: Sheep Agrosilvopastoral	■	■				■		
	A03: Irrigated Arable Farming	■				■			
	A04: Olive Farming	■	■		■	■	■	■	■
	A05: Annual Cropping Central		■			■	■		
	A06: Vine Farming			■	■		■		
	A07: Annual Cropping North		■			■	■	■	■
	A08: Annual Cropping South			■	■	■			■
	A09: Organic Mixed Farming East	■	■			■	■		
	A10: Mixed Farming North		■	■	■	■	■		■
Forestry	F01: Forest North		■		■				
	F02: Forest Peatland Northeast		■				■		
	F03: Forest Tourism Southeast		■			■	■		
Mixed	M01: Agroforestry in Dehesa	■	■			■	■		■
	M02: Alpine Tourism		■	■	■	■	■		■
	M03: Peatlands		■		■		■		
	M04: Reforestation				■	■	■		
Urban and Post-Industrial	U01: Post-mining			■	■				■
	U02: Dense Urbanism			■	■		■		■
	U03: Post-minig				■	■			

Figure 4-1:Soil mission objectives in the regions

Stakeholder Interaction

The outreach and preparation for the workshops and interviews was conducted with a thorough stakeholder analysis of the selected region. Depending on the land use type and local context, varying stakeholder groups were contacted. The knowledge developed in the Work Package 1 on the stakeholder engagement guidelines of the PREPSOIL project was adapted to develop the stakeholder categorisation and analysis.

In total, 577 stakeholders participated in the 20 workshops (Please refer to Figure 4-2 and Table 4-1 for additional information). The main categories of stakeholders are policy and government, research, soil and other advisors, farmer/land user, business, CSO and NGOs. While engaging with the stakeholders, the Soil Mission was presented to the audience and intensive discussions were held in each region. The glimpse of these stakeholder interactions can be observed at https://prepsoil.eu/soil-by-region.

Table 4-1: Number of stakeholders and stakeholder categories participating in the workshops of each land use category.

Land Use/Stakeholder Group	Policy and Government	Research	Soil and Other Advisors	Farmer/ Land User	Business	CSO and NGO	Total
Agriculture	38	87	63	80	31	48	347
Forestry	15	26	5	34	0	10	90
Mixed	15	16	22	11	1	13	78
Urban and Post-Industrial	24	22	4	2	4	6	62
Total	92	151	94	127	36	77	577

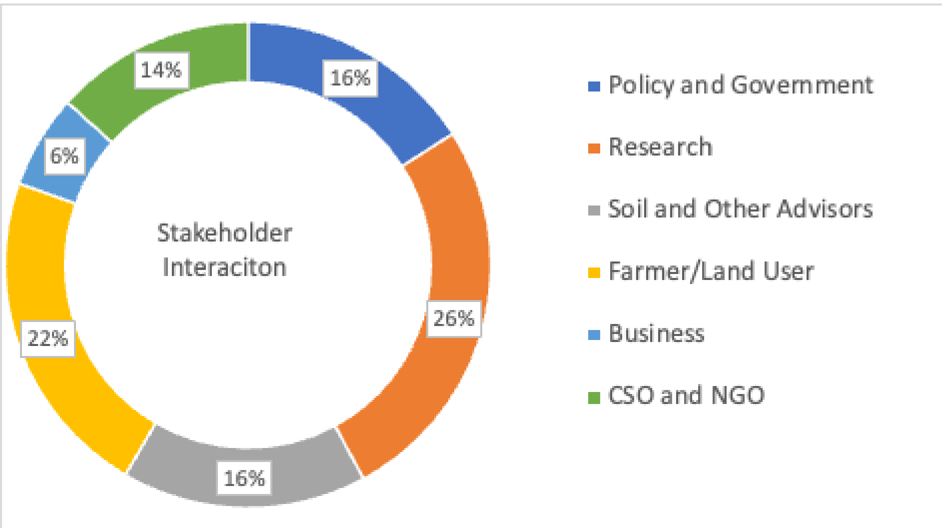


Figure 4-2: Share of stakeholder categories participating in the regional soil needs assessments.

4.1 Agricultural Land Use

The socio-economic system has affected agricultural soils for centuries. Specific to their agricultural production system, the challenges and threats to soils vary accordingly. Most of the analysed cases have experienced substantial intensification of agricultural production during the last decades, followed by a deterioration of the biological, chemical, and/or physical states of agricultural soils and a subsequent decrease in ecosystem services. While intensification has ensured the economic survival of agricultural farms for decades, their resilience is increasingly declining in the face of climate change, price volatility, and other shocks. This trend makes a transformation of the agricultural system necessary in most regions and is required from both a socio-economic and environmental perspective.

4.1.1 Drivers for soil health in agriculture land uses

The agricultural production system is influenced by a variety of complex, interrelated, and self-reinforcing drivers. The land use history strongly affects today's decision-making, as cultural identity, ownership, and a sense of belonging to an area are part of humanity. The resulting path dependence is reinforced by extension service providers and their attitudes towards agricultural production, as well as sunk investments in machinery and equipment that counteract the possibility of sudden changes. Contrary to other sectors, agricultural production actors plan for decades rather than years. Additionally, land-tenure systems, former investment decisions, and the resulting contractual obligations stabilize the current trajectory. The need to maintain economic profitability in face of global trade conditions poses an opportunity for efficiently producing farms but is at the same time a threat to the existence of an aging rural population, which has difficulties finding successors in many regions. Technology developments and direct area-based common agricultural policy (CAP) payments have boosted production and economic efficiency for decades. Aided by increasing external inputs (mineral fertilizers, pesticides), simplifying production, and concentrating on a few commodities per farm and region. The agricultural production system is urged to adapt to climate change effects such as higher average temperatures, prolonged periods of drought (lower groundwater table, less precipitation), and an increased frequency of severe rainfall events. These events may pose an increasing threat to erosion processes. Policy initiatives under the CAPs II Pillar and its regional development plans have in part been introduced to counteract negative environmental impacts.

4.1.2 Pressures on soil health through land and soil management in agricultural land uses

Any agricultural production activity interferes with the soil and has, in many agricultural production contexts, been reported to affect soil health negatively. Commonalities in all cases emphasize the use of heavy machinery and intensive tillage (plowing). Some regions have started to transform, in part, to no-till or reduced-tillage systems. However, the intensity of agricultural production remains high in some contexts and production systems e.g. for grains (East Denmark, Brandenburg, Emilia-Romagna); for intense livestock (Gelderland). This finds expression through high stocking rates in livestock production systems and high input (fertilizers, pesticides), specialized arable systems with simplified crop rotations and a concentration on very few, economically rewarding crops, and simplified landscape structures. Specialization in livestock production, driven by CAP subsidies, has led to very sub-regionally centred high stocking rates. Livestock overproduction in one part of a region leads to high nitrogen concentrations and respective water contamination through leaching and surface runoff. Arable production in other parts of the regions is based on mineral fertilizers because of scarcities of livestock-based manure. In addition to the simplification of landscape structures and crop rotations, inputs of pesticides and herbicides negatively impact the soil and aboveground biodiversity; nonetheless, decreased pesticide use may lead farmers to increase their tillage activities. Latest trends are pointing in two directions: On one side, digitalization, and high-tech precision agriculture systems (e.g., drip irrigation, sensors, autonomous machinery) provide scope for further production efficiency and, if governed well, natural resource savings. On the other hand, regenerative agriculture, agro-ecology, and trends in the revitalization of traditional production systems, centred around community-based approaches, lead away from dependence on external input and put the performance of the ecological, soil-based system back in the foreground, partly linked to the revitalization of local and regional value chains.

4.1.3 Soil health states and their dynamic in agricultural land uses

The most detrimental to soil health is artificial sealing. Increasingly, soils in economically prosperous regions increase the built-up environment on former farm- or grassland, outside of municipalities or in urban agglomerations. In annual cropping production contexts, soil compaction due to heavy machinery and lost proportions of deep-rooting plants in the rotation limits water infiltration and retention capacity. The intensity and frequency of soil tillage activities destroy soil structure, reduce aeration, and water retention, and limit the habitat for the soil fauna and microbiome. Most arable regions are experiencing a decline in soil organic carbon due to simplified crop rotations or monoculture production systems. While livestock systems have less effect on soil compaction and soil organic carbon decline, when based on pasture fodder production, the production of grains for feed has the same soil health limitations (compaction and decline of soil organic matter). Intensive manure application in livestock-based systems and mineral fertilization (N-P-K) in arable systems lead to high nitrogen concentrations in the soil-water interface and consecutive leeching in and eutrophication of connected water bodies and ecosystems. Wind and water erosion processes are widespread in the researched regions as landscape simplification with the removal of linear elements and enlarged field sizes, frequent tillage, and the lack of soil cover leaves bare soils for extended periods of time. The commutation of these effects in combination with changing weather patterns may lead to almost irreversible desertification processes, especially in arid, already water-poor regions in Europe.

4.1.4 Impacts of land and soil management induced soil health dynamics in agricultural land uses

Soil ecosystem services are related to soil functions and include provision services (e.g., biomass for food, feed, fibre, and clean water), regulation and maintenance services (water purification and retention, cooling), cultural services (heritage, recreation), and the provision of biodiversity, which by mass is estimated to be much larger belowground (in the soil) than aboveground. The impacts on ecosystem services in the researched regions vary depending on the services they provided in the past and the current main production system. In water-scarce places, soil degradation is causing a significant decline in the ability of ecosystems to regulate water retention. This is particularly true in areas where tillage activity has negatively impacted the storage and regulatory capabilities of the soil. The situation is reaching a critical point from which recovery may be impossible. Consequently, both droughts and floods may be more severe, with detrimental effects far beyond the agricultural system. With modern production technologies, the provision of biomass of food, feed and energy is well achieved. However, the loss of biodiversity and the increasing loss of nutrient recycling on naturally fertile land are increasing and will increase the risk of biomass production failures (e.g. harvest failures). Additionally, the simplification of landscapes for agricultural purposes and the monocropping activities lead to reduced resistance against pests, diseases, and invasive species. A change in the production system due to changing consumption preferences for food products may drastically lead to a change in cultural services and identity as regions lose their main products.

4.1.5 Response which can reinforce positive trend and limit negative trends regarding soil health in agricultural land uses

Responses of agricultural systems to the above-described cumulating of external drivers, pressures, soil health deterioration, and the noticeable impacts on ecosystem services vary in degree in each region. While no-till or reduced-tillage practices, diversified crop rotations, lighter machines, robotics, and precision farming are approaches that limit disturbances in soils, their adoption by farmers has not spread sufficiently to change the trend of soil health decline yet. The lack of adequate agricultural knowledge and information systems applies for most studied regions. An issue raised is the CAPs dual approach of pillars I and II, which are considered to balance each other, while bureaucratic and administrative hurdles for Pillar II funds remain high and uncertainties about whether a measure will exist in the next funding period prevail. Regions experiencing climate change are adapting by means of diversification in crop rotations or introducing new crops. Replacing area-based payments (CAP, Pillar I) with remunerations for agriculture-based provision of ecosystem services combined with a coherent soil protection policy would introduce a new common standard for farmers in Europe. For some regions, the dependency on international trade for their products is so large that the competition on the world market would need changing to adequately respond to intensification processes and remain within production limits conducive to soil health (e.g., Bordeau, Brandenburg, Sardinia cases). Regions experiencing climate change are adapting by means of diversification in crop rotations or are introducing new crops, under the limitation of financial possibilities. More likely in some regions is the abandonment of the farming sector as a final response to the current system.

4.1.6 Soil Needs in agricultural land use

Agricultural production systems are the most diverse in the case studies considered in the study. Soil needs in this land use require a systemic change to increase soil health. An adaptation to the drivers of progressing demographic changes in the future are already felt today, as land abandonment and the exit from the farming sector by substantial amounts of population continues. Soils may be affected negatively by sudden abandonments of land in very rural areas. Simultaneously, climate change and its effects are a major factor in all production system, adapting to it is a major threat for healthy soils and ecosystem services. Like forested monocultural practices, agricultural monocultures and the most intense production systems need to diversify and change to contribute to soil health. Innovation by the adoption of innovative technologies, may on the one hand increase production by gaining efficiency and on the other lead to compensation of less farmers.

4.2 Forest and Nature Land Use

The case study regions for forested and nature areas on mineral and peat soils include Antalya in Turkey (the Körprülü National Park), the Soomaa National Park in Estland and Upper Norrland in Sweden.

4.2.1 Drivers for soil health forest land uses

Climate change, timber industry, and eco-tourism are key drivers for changes in soil management and soil health in the forestry cases in Sweden, Estonia, and Turkey. While geophysical and socio-economic conditions are completely different in the three cases, they have these three drivers in common. In the northern regions (Sweden, Estonia), climate change is expected to have mixed effects, including extended drought periods during summer, and shortened frost periods during winter, which pose challenges to forest operations and increase the risk of compaction. In the southern region (Turkey), climate change increases irrigation needs and aggravates the risks of forest fires, which, although a natural element of the ecosystem, may emerge as severe damage and a risk for population and infrastructure. Forestry in the northern countries (Sweden, Estonia) triggers mono-cultivation and clear-cutting for improved economic return. Eco-tourism is an increasing factor for the economy in two of the three regions (Estonia, Turkey), taking advantage of the landscape scenery and environmental beauty and leading to soil and land management changes in the northern cases (Sweden, Estonia), where economic forest management prevailed. The increasing societal valuation of forest-related ecosystem services and the outburst of bark beetle pests are further important drivers for forest management changes.

4.2.2 Pressures soil health through land and soil management in forest land uses

Diverging land management trends lead to mixed pressures on the soil system. One key pressure result from eco-tourism development (Estonia, Turkey), which reinforces nature conservation trends in the forest regions because eco-tourism is bound to nature experiences and landscape scenery. In the northern cases of forest timber production (Sweden, Estonia), a transition towards more ecological forest management is observed. This includes the replacement of coniferous monostands by mixed forests, a continuous forest cover, and the harvesting of only the stems while the tops and branches remain on the soil surface as logging residues to cover the soil and avoid soil compaction during harvest and forest operations. In areas where peat soils are prevalent, restoration of the peatland ecosystems, including rewetting of formerly drained peatland, is a major activity. In the southern case (Turkey), nature conservation leads to increased soil sealing because of the development of transportation infrastructure and housing. Increasing amounts of solid waste and wastewater are another consequence of eco-tourism development in this region. Climate change-induced water management in the agricultural areas surrounding the forest lands impacts on forest vegetation and soil health due to reinforced irrigation in the southern region and reinforced drainage in the northern region (Estonia).

4.2.3 Soil health states and their dynamic in forest land uses

Soil health dynamics differ across the forest cases. In the northern cases (Sweden, Estonia), peatland soils suffered severe degradation in the past because of comprehensive drainage systems installed, partially followed by the introduction of monocultural forest systems. Today, rewetting of the peatland is already improving soil organic carbon sequestration and peatland growth. Soil compaction and decreased water retention capacities following heavy machinery forest operations in wet soils (climate change-induced winter flooding) are a more recent negative trend in soil health in managed forests. Clear cutting of forest stands also leads to water erosion in hilly landscapes and wind erosion in dry situations, a process that may aggravate because of the higher frequency of severe winds induced by climate change. In the southern case (Turkey), increased soil erosion on unmanaged land and soil organic carbon deterioration in forest fire-affected areas lead to soil degradation. Contamination with unmanaged waste from tourism activities may emerge as a further soil health problem, which is, however, not yet well understood or monitored.

4.2.4 Impacts of land and soil management induced soil health dynamics forest land uses

On the one hand, soil and land management changes have direct impacts on socio-economic dynamics in the forest regions. Eco-tourism is newly established as a major economic activity and source of income in both regions, thereby partially replacing agriculture and forestry as major income sources. Since eco-tourism relies on ecosystem integrity, it may further reinforce soil health in the long term if managed well. On the other hand, land and soil management-induced changes in soil health may have an incredibly positive impact on climate change mitigation in the northern cases (Estonia, Sweden), since increased carbon sequestration of the rewetted peatland acts as a natural carbon sink to the atmosphere. Given the fact that drained peatlands contribute 5% to total greenhouse gas emissions worldwide, the rewetting of peatland can be seen as a major contributor to climate change mitigation. However, rewetting could often be accompanied by the enhanced release of toxic metals (methylmercury) and phosphorus, thereby deteriorating water quality. This negative effect offsets the environmental objective of 'zero eutrophication' and is a trade-off that could come along with increased carbon sequestration in peatlands. In the southern case, nature conservation activities do not seem to be able to cope with pressures related to tourism development and climate change yet, so that soil erosion and forest fires lead to negative impacts on water quality and biodiversity and may also lead to increased risks for human health.

4.2.5 Response which can reinforce positive trends and limit negative trends regarding soil health in forest land uses

Since in all forest cases, socio-economic activities emerge to rely on ecosystem integrity (eco-tourism and recreation) rather than on natural resource exploitation (timber production), the potential for soil health improvement is high. It is at the same time a promising solution for climate change adaptation and mitigation since climate change will severely challenge economic forest management in the future (increasing winter floods and extended summer droughts in the north and water scarcity in the south). Yet, water management in agricultural areas neighbouring the **forest areas** still threatens restoration efforts: water drainage systems in the north and irrigation systems in the south. In the northern case (Estonia), agricultural drainage systems and respective peat soil degradation are even incentivized through the current CAP system. Altering the CAP system to incentivize ecosystem service provision such as soil organic carbon sequestration or biodiversity conservation would, in both cases, facilitate ecosystem restoration efforts and improve the likelihood of soil health improvements. Yet, a trade-off with water quality may occur because of a phosphorus release from rewetted peat soils. Here, a landscape approach to land management is required that takes into consideration the interactions between different soils and land use systems at watershed levels. Education for improved soil literacy is a further lever for soil health; forest management education does not yet sufficiently include the management of forest soils.

4.2.6 Soil needs in forest and nature land uses

Forests predominate in locations where water availability and altitude allow for tree growth but not for agricultural cultivation. Forests range from natural, even pristine forests to monocultural systems for the timber industry. In the northern countries, forests are mostly cultivated on nutrient-poor soils and on rocky morainic material which are without concurrence to any other land uses and on drained peatlands, with the consequences for soil organic carbon deterioration and respective CO_2 emissions. Natural forests are of high quality for recreation and many ecosystem services.

Soil needs in forested and nature areas require adaption of forests to climate change (drought, fires), especially in monostands and coniferous plantations by the adoption of different management techniques. The long-term implications of forested areas require action now, to reimagine forests as mixed stands, due to long time horizons in tree succession. Soil needs in nature areas with tourist activities require a management concept which does not exert too many pressures on soils, such as the sealing of areas for visiting areas. Peatlands require a different approach as forests for comprehensive forestry, as here CAP policy need to change for soils to increase their health.

4.3 Urban and Post-Industrial Land Use

Soils in the urban and industrial areas are stressed due to the current and ongoing intensity and competition among diverse uses. The urban population is constantly increasing, and cities are also expanding physically to accommodate their needs, and this is reflected in all three cases: U1 Post-industrial (Upper Silesia, Poland), U2 Urban (Amsterdam, Netherland), and U3 Post-mining (Zasavje, Slovania).

4.3.1 Drivers for soil health in urban and post-industrial land uses

Due to the cases having vastly different socio-economic and environmental settings, many drivers with unique characteristics have been identified for the urban and industrial areas, but few parallels can be drawn, such as climate change (increasing temperatures/heat and excessive rainfall) and societal/demand changes. In the case of metropolitan Amsterdam, citizen awareness and participation are key to localizing the greening transition with community-led activities and raising awareness regarding soil health. Such initiatives are part of an even larger advancement in planning and technology to support green initiatives such as introducing nature-based solutions and using the subsurface to optimize the use of land. The lack of such awareness and policy development have been identified as drivers (or supposed barriers) that would be detrimental to ensuring soil health and positive changes in the future. Even with greening policies and awareness programs in place, extreme competitiveness over land in urban areas can trigger changes in unfavourable directions. For the post-industrial and post-mining landscapes, land use is undergoing a transformation due to changes in economic activities such as the closure of mines and industries, but the impact of the past legacies on these regions is deeply ingrained and expected to be felt for some time in the future and is expected to dictate the future change trajectories. The closure of the previous key economic activities also means the need to establish new ones as replacements, which, if not sufficient, can result in demographic fluctuations in the form of immigration or labour exports.

4.3.2 Pressures on soil health through land and soil management in urban and post-industrial land uses

The main pressure in urban and industrial areas is unequivocally identified as urbanization forcing soil sealing. Although Amsterdam is understandably expanding to accommodate its rapidly growing population, urban land take in post-industrial and post-mining landscapes is continuing and expected to continue due to the need to build infrastructure to support societal (e.g., suburban accommodation complexes in Poland) and economic (i.e., new commercial and industrial centres in Poland and Slovenia) needs. Unsuitability of the land to promote alternate economic activities, such as agriculture, to reduce built-up land use is not always possible because the soil is either unsuitable (as in Slovenia) or the practice is insufficiently relevant (i.e., Amsterdam). Industrial pollution is identified as the primary soil pressure in the post-mining and industrial region in all cases. In the case of Amsterdam, current land use is problematic. Contamination is not limited to previous mining sites; contamination can be found in streams (e.g., Slovenia) and surrounding forest areas (i.e., Poland). The need for contaminated site remediation is a constant source of stress for urban municipalities.

4.3.3 Soil health states and their dynamic in urban and post-industrial land uses

Continuing the discussion of soil contamination pressures, it also provides a general outlook on the state of urban soils. Contamination is typically associated with past activities, but ongoing activities (for example, spillage in Amsterdam's harbour) and the type and spread of contaminants are also site-specific. Soil contamination in urban and industrial areas is persistent, multifaceted, and complex, and requires intervention. Soil sealing and compaction are two other soil health parameters that are harmed by urban and industrial activities. Soil organic carbon (SOC) content in urban soils is rarely measured, but it is likely to be low. Salinization is unique to Amsterdam, but it may become a growing issue in coastal cities because of sea level rise. Soil erosion in urban soils is also expected to worsen because of climate change. Citizens' awareness of soil health is inconsistent across cases, but it is low in all cases. In addition, at the planning and policy levels, there is a lack of a comprehensive approach to urban soil health.

4.3.4 Impacts of land and soil management induced soil health dynamics in urban and post-industrial land uses

The impact of the drivers (as well as pressures and state) is difficult to estimate, since urban and industrial soils are frequently overlooked in research and monitoring. It is assumed, that climate change and existing soil contamination will have a negative impact on all soil health metrics. Habitat and biodiversity are metrics where there is insufficient data to estimate an impact but where climate change is expected to have a negative impact. Climate change will also have an impact on urban soils' ability to regulate temperature and increase the risk of extreme events like flooding. Consistent urban land take also means that increasingly productive agricultural and forest land will be lost, which has been identified in Poland as significantly reducing soil production capacity.

4.3.5 Responses which can reinforce positive trend and limit negative trends regarding soil health in urban and post-mining land uses

Responses in urban and industrial areas are both general, addressing broader issues, and specific, addressing specific situations and output. In the case of Amsterdam, local policy regarding urban soil health is expected to be passed. The municipality has also considered creating an urban soil health index to provide definitions and monitoring requirements for urban soil health. Such policy initiatives are lacking in Poland and Slovenia, where the need is recognized but intervention is not guaranteed. Responses are more specific, such as the implementation of cycle paths in Slovenia and the introduction of urban greening and agriculture in Poland. These responses will result in positive changes, but they may be insufficient considering the magnitude of the problem.

4.3.6 Soil needs in urban and post-mining land use

Soil needs requirements in urban areas differ from those in post-mining areas. Soils in urban areas are heavily influenced by land use within the city. The urban planning system is critical in this process. Concurrently, political processes determine the outcome of city planning. As a result of their unique characteristics, soils in urban contexts have different requirements (parks, gardens, cemeteries, playgrounds, built-up areas, recreational areas, and infrastructure).

Finally, multifunctionality of soils in urban contexts may not be fully realized in cases where a specific function is predetermined by an area's planning and zoning requirements. These vary across European regions (Reimer et al. 2014). A consistent goal orientation should be to limit soil sealing as much as possible and to de-seal previously sealed soils for restoring important soil functions in the process.

However, land-use changes in post-mining areas are closely related to issues encountered in the cases for forests, agricultural, and mixed land uses. The system's previous function was to extract minerals from the bedrock and coal for human consumption. In the process of leaving behind hazardous excavations, the transformation of a system in search of a new function causes new disturbances in the soil as new land uses emerge (tourism, agriculture, forestry). The requirements for urban and post-mining land use rely on careful participatory planning, with ecosystem services considered from the start. The emphasis in a post-mining context should be on the reconstitution of ecosystem services.

4.4 Mixed land use

The regions with mixed land use include agroforestry (Spain, Czech Republic), Alpine tourism-agriculture (France), and peatlands (Ireland). Mixed land use regions have high economic potential and provide greater ecosystem services.

4.4.1 Drivers for soil health and land management in mixed land uses

The key drivers in mixed land use regions are soil properties, climate change, shifting patterns of farming (cattle-to-sheep, sheep-to-cattle, monoculture), lack of access to knowledge, resources, and training, and poor cooperation among the land users and policymakers. Poor soil structure, low income from farming and land use drive anthropogenic activities such as pastoralism, agroforestry, alpine pastoralism, tourism, and agriculture. Climate change, with differentiated patterns of intensified heat (heatwaves), increasing temperatures, reductions in rainfall and snow, torrential rains, and receding glaciers, drives soil health and land management. These changes aggravate existing natural risks in mountain and forest regions, including floods, landslides, erosion, and fires, and further restrict land management.

The rural exodus and lack of generational renewal and skilled labour, in combination with short-term land tenure arrangements, create fewer incentives for land users (farmers, forest owners, and resort owners) to invest in long-term soil health improvements. Cultural heritage, reverse migration to rural areas, and tourism activities generating income are creating land use conflicts. The CAP policy drives the shifts in farming practices such as sheep-to-cattle farming in mountainous areas (France), cattle-to-sheep farming (Dehesa system in Spain), rewetting peatlands (Ireland), and monoculture of forests and crops (Czech Republic). The procedures for claiming environmental payments are very complex and bureaucratic, hindering further land users from implementing sustainable land management measures. However, the land users lack access to knowledge, cooperation platforms for communities, knowledge on soil health and improvement possibilities, effective communication, and knowledge exchange among farmers and advisors.

4.4.2 Pressures on soil health through land and soil management in mixed land uses

Climate change and changes in the socio-economic situation in mixed land use regions created interlinked pressures on soils in agriculture, pastoral, touristic, and forest regions. In agriculture, due to climate change and economic decline, farms intensified and became either larger or fragmented. Competition for irrigation, grazing, and forest or recreation is increasing in all the regions, irrespective of the land use needs. The lands adjacent to villages were overutilized, while the agricultural lands in the forests and mountains were abandoned.

Pastoral activities were limited or reduced by regulations on livestock numbers, land use categorization, and climate change. The type and number of livestock were changed, while the grazing areas increased but were limited to lowlands in Dehesas and mountain regions in France. Forest restoration reintroduced wolves, which limited the grazing animals to fenced areas. The concentration of livestock for grazing created additional pressure on the soil in the fragile areas.

The agroforestry systems, forests, peat forests, and alpine regions in general are poorly managed. Land use categorization (summer grazing, sloping pastures, mountain hat meadows), the greening phenomenon-expansion of forests into the sub-alpine zone are implemented in mixed land use regions. Monoculture practices, in combination with heat stress on spruce trees, resulted in the drastic loss of forests due to bark beetle occurrences in the Czech Republic. The lack of stewardship due to the implemented tenure system resulted in poor forest management (litter removal in the Czech Republic) and further degradation of forests.

Tourism activities are further transforming to adapt to changing climatic patterns. This leads to an expansion into new seasons, conflicting with other land uses (pastoral, agriculture, and forestry), creating alternative income sources for locals. The wilderness of the forest, cultural heritage is prioritized to align with carbon neutrality targets, particularly through the private investments. While pastoral and farming activities are suffering from a lack of access to financial resources, private investments in the tourism sector push for the reintroduction of wilderness areas.

4.4.3 Soil health states and their dynamic in mixed land uses

The soil health in mixed land use regions is considered degraded and prone to high risk in the future. Monocultural practices, in combination with climate change, resulted in the degradation of soils in all terrains. Fertility of soils in monocultural areas was reduced, and carbon storage capacity has been limited in farming areas. Climate change induced soil erosion resulted in the loss of fertile soil, organic matter, nutrients, and biodiversity, which is observable in all regions. Changes in the farming systems, land use categorization, shifts in grazing practices, invasive species appearances in forested areas, and the expansion of tourism activities further reduced soil health. Land abandonment of agroforestry lands, grazing areas, and poorly managed forests is observed.

Farmers and landowners are increasingly dependent on external sources for investments in land improvements. The land tenure practices reduced the stewardship and motivation of tenured farmers to invest in sustainable land management measures that would support ecosystem services. The loss of biodiversity, degraded forests, and reduced wilderness are directly affecting farmers income through the loss of reputation, some of which has high heritage value.

Recent phenomena such as increasing pest occurrences, invasive species (new species migrate to warmer climates), nutrient leaching, herbicides used in agriculture and livestock systems, and litter in tourists' areas have caused soil pollution. Climate change leads to the melting of glaciers and increased atmospheric nitrogen deposition on soils, the appearance of new ecosystems on proglacial margins, and faster and higher tree mortality in pest-infested forests. The impacts of these new ecosystems on soil health are unknown.

4.4.4 Impacts of land and soil management induced soil health dynamics in mixed land uses

Practices in regions with mixed land uses pose varied impacts on ecosystem services. Pastoral, agricultural, peat, and forest land have been degraded. As a result, the overall biomass production needed to sustain the livelihood of land users is reduced. Soil erosion impacted major soil ecosystem services. The loss of soil fertility, reduction in biodiversity and carbon sequestration, and reduced water holding capacity of the soils are observed. Natural hazards (floods, landslides, and forest and peatland fires) have increased in these regions. Further, reduced microbial activity, increased pest and disease susceptibility have been reported. The reduction in soil fertility and poor management practices lead to a direct reduction in the production of food and fibre. As a result, water quality and availability for farming practices have been reduced, impaired water infiltration, and increased vulnerability to soil erosion.

Changes in farming practices, expansion of tourism zones, and degraded forests are impacting carbon storage negatively. Whereas, the rewetting of peatlands, land use categorization, dedicated grazing zones, reforestation, expansion of natural vegetation, and agroforestry measures improve carbon storage and other ecosystem services.

4.4.5 Response which can reinforce positive trend and limit negative trends regarding soil health in mixed land uses

The soil health improvement response in the mixed land use regions is addressing the key problems of climate change, soil properties, land use changes, and improving cooperation and land users' literacy. It is evident that the improvement in soils is essential for the improvements in socio-economic status and, thus, the overall ecosystems.

Different soil health measures tailored to regional characteristics are implemented in agroforests in dehesa systems, reforestation in the degraded forests in the Czech Republic, rewetting peatlands in Ireland, and land use categorization in Alpine regions. A combination of technical measures and nature-based solutions is prioritized, such as zero tillage, diversified crop rotations, precision farming, optimizing irrigation schedules, sustainable harvesting techniques, smart grazing, reforestation suitable to local conditions, forest litter removal, preservation of the soil top layer, limiting land take, restoration of degraded (peat)lands, and limiting pesticide use. These measures further focus on improving ecosystem services such as water holding capacity, carbon storage, and diversification. Diversifying forest composition and integrating mixed-species forests are also prioritized to enhance resilience to climate change. Advanced technological solutions (precision farming, earth observation, sensor measurements, and citizen science) tailored to regional climatic and socio-economic conditions are developed to monitor soil quality and improve farm productivity.

4.4.6 Soil needs in the mixed land use

The policy response towards the economic improvements and capacity building were emphasized as future demands. Additionally, soil needs in mixed land uses are a mixture of agricultural and forested areas and only slightly differ in their needs. As several production systems may be combined in one landscape, several policies may overlap to regulate the systems. This circumstance may result in a high complexity in these regions concerning land management decisions and soil needs.

5 References

Costanza, R., d'Arge, R., Groot, R. de, Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van den Belt, M., 1998. The value of the world's ecosystem services and natural capital. Ecological Economics 25 (1), 3–15. 10.1016/S0921-8009(98)00020-2.

European Commission. 2021. European Missions. A Soil Deal for Europe. Implementation Plan. Brussels.

European Commission. 2021. COM/2021/699 final. Soil Strategy for 2030 Reaping the benefits of healthy soils for people, food, nature and climate. Brussels.

European Environmental Agency, 1999. Environmental indicators: Typology and overview, Copenhagen.

European Environmental Agency, 2019. The European environment - state and outlook 2020: Knowledge and transition to a sustainable Europe. EEA, Luxembourg.

European Environmental Agency, 2016. Urban sprawl in Europe. EEA-report 11/2016. Publications Office of the European Union, Luxembourg.

Ford, D. N., 2019. A system dynamics glossary. Syst. Dyn. Rev. 35 (4), 369-379. 10.1002/sdr.1641.

Helming, K., Daedlow, K., Hansjürgens, B., Koellner, T., 2018. Assessment and Governance of Sustainable Soil Management. Sustainability 10 (12), 4432. 10.3390/su10124432.

Jordan, A., Lenschow, A., 2010. Environmental policy integration: a state of the art review. Env Pol Gov 20 (3), 147–158. 10.1002/eet.539.

Keesstra, S.D., Bouma, J., Wallinga, J., Tittonell, P., Smith, P., Cerdà, A., Montanarella, L., Quinton, J.N., Pachepsky, Y., van der Putten, W.H., Bardgett, R.D., Moolenaar, S., Mol, G., Jansen, B., Fresco, L.O., 2016. The significance of soils and soil science towards realization of the United Nations Sustainable Development Goals. SOIL 2 (2), 111–128. 10.5194/soil-2-111-2016.

Löbmann, M.T., Maring, L., Prokop, G., Brils, J., Bender, J., Bispo, A., Helming, K., 2022. Systems knowledge for sustainable soil and land management. The Science of the total environment 822, 153389. 10.1016/j.scitotenv.2022.153389.

Mayring, P., Fenzl, T., 2019. Qualitative Inhaltsanalyse, in: Baur, N., Blasius, J. (Eds.), Handbuch Methoden der empirischen Sozialforschung, 2., vollständig überarbeitete und erweiterte Auflage ed. Handbuch. Springer VS, Wiesbaden, pp. 633-648.

Moon, K., Blackman, D., 2014. A guide to understanding social science research for natural scientists. Conserv Biol 28 (5), 1167-1177. 10.1111/cobi.12326.

Reimer, M., Getimis, P., Blotevogel, H., 2014. Spatial Planning Systems and Practices in Europe. 10.4324/9781315852577.

Tesfai, M., Øygarden, L., Hessel, R. (2015). Soil threats in Europe, https://data.europa.eu/doi/10.2788/828742

Timmermans, S., Tavory, I., 2012. Theory Construction in Qualitative Research. Sociological Theory 30 (3), 167-186. 10.1177/0735275112457914.

Turner, B., Menendez, H., Gates, R., Tedeschi, L., Atzori, A., 2016. System Dynamics Modeling for Agricultural and Natural Resource Management Issues: Review of Some Past Cases and Forecasting Future Roles. Resources 5 (4), 40. 10.3390/resources5040040.

Sterman, J.D., 2009. Business dynamics: Systems thinking and modeling for a complex world, Irwin/McGraw-Hill, Boston.

Paul, C., Kuhn, K., Steinhoff-Knopp, B., Weißhuhn, P., Helming, K., 2020. Towards a standardization of soil-related ecosystem service assessments. Eur J Soil Sci. 10.15488/12657.

United Nations. 2023. The Sustainable Development Goals Report. Special edition.

Vaccaro, I., Smith, E.A., Aswani, S. (Eds.), 2010. Environmental social sciences: Methods and research design. Cambridge University Press, Cambridge.

Visser, S., Keesstra S., Maas, G., Molenaar, C. 2019. Soil as a Basis to Create Enabling Conditions for Transitions Towards Sustainable Land Management as a Key to Achieve the SDGs by 2030. Sustainability 11 (23). 10.3390/su11236792.

Yin, R.K., 2018. Case study research and applications: Design and methods, Sixth edition ed. SAGE, Los Angeles, London, New Delhi, Singapore, Washington DC, Melbourne.

Vennix, J.A.M., Gubbels, J.W., 1992. Knowledge elicitation in conceptual model building: A case study in modeling a regional Dutch health care system. European Journal of Operational Research 59, 85–101.

Zare, F., Elsawah, S., Bagheri, A., Nabavi, E., Jakeman, A.J., 2019. Improved integrated water resource modelling by combining DPSIR and system dynamics conceptual modelling techniques. Journal of environmental management 246, 27-41. 10.1016/j.jenvman.2019.05.033.

Vennix, J.A.M., Gubbels, J.W., 1992. Knowledge elicitation in conceptual model building: A case study in modeling a regional Dutch health care system. European Journal of Operational Research 59, 85–101.

6 Annexure 1: Regional Briefs of the 20 Soil Needs Assessments in Europe

7 Annexure 2: Guidelines of the Soil Needs Assessment

8 Annexure 3: DPSIR Elements Related to the Soil Needs Assessment

9 Annexure 4: Questions Repository

10 Annexure 5: Reporting Template

11 Annexure 6: Results from Soil Mission Event in Madrid

12 Annexure 7: Soil Needs and Drivers of Change Across Europe and Land Use Types

Annexures

Annexure 1: Regional Briefs of the 20 soil needs assessments across Europe

Annexure 2: Common assessment procedures of the soil needs in representative regions across Europe

Annexure 3: DPSIR elements related to the soil needs

Annexure 4: Questions repository

Annexure 5: Reporting template for the "Common Assessment procedure for soil needs in representative regions across Europe"

Funded by the European Union

Table of Content

List of Figures

List of Tables

Annexure 1 Regional Briefs of the 20 soil needs assessments

1. Cow Dairy Farming: Gelderland, Netherlands

Menno Diersmann (WENR, menno.diersmann@wur.nl), Saskia Keesstra (WENR, saskia.keesstra@wur.nl); Chantal Hendriks (WENR chantal.hendriks@wur.nl)

1.1 Regional Information

The region includes the areas of Arnhem-Nijmegen and Achterhoek. Urbanization and industrialization of the rural area are threatening the rural area of Arnhem-Nijmegen, whereas intensive agriculture close to Natura 2000 areas is causing environmental issues in Achterhoek. The area is situated in the eastern part of the Netherlands (Figure 1-1) and includes 11 municipalities. The geographic boundaries of the region are the Ijssel River in the west, the cities Arnhem and Nijmegen, and the German border in the south and east.

The region has a rich variety of soil typesand is dominated by grassland and arable land (Figure 2-3). In the last ice age (i.e., Weichselian), wind erosion left a layer of cover sand (Miedema, 1993). Due to agricultural activities, these sand dunes eroded again, which resulted in inland drift sand areas. In the northern part of the Arnhem-Nijmegen region, these inland drift sand areas belong to a Natura 2000 area (Veluwe). At the higher and dryer sandy soils, podzols or anthrosols developed depending on the agricultural activities (i.e., the plaggic system). In the lower valleys and along the rivers, fluvisols developed (Fujita & Ros, 2021).

The area houses about 3.8% of the national pigs and 2.5% of the dairy cattle (Rougoor & van Well, 2016). The region is 1.476 km² of which a large part is agricultural land. About 70% of the agricultural land is grassland, and 30% is arable land (Table 1-1). The region includes intensive and extensive agriculture (Rougoor & van Well, 2016). Intensive agriculture resulted in nutrient (especially nitrogen) surpluses in the soil and a high use of chemical pesticides to prevent pests and diseases. Consequently, groundwater and surface water eutrophicated, biodiversity declined, and the resilience of the landscape decreased. The less intensive farming systems occur increasingly on the borders of natural areas. Irregular parcels with hedges and/or thickets (i.e., 'coulissen' landscape) used to be prominent in the region before intensive agriculture was widespread. Currently, this way of organizing the landscape is slowly making its comeback.

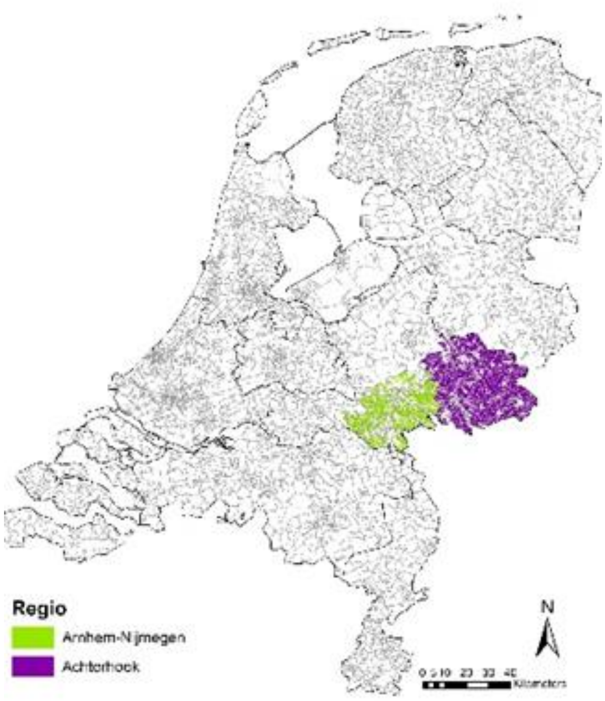


Figure 1-1:The Arnhem-Nijmegen region (green), Achterhoek region (purple) represent the Southeast Gelderland region.

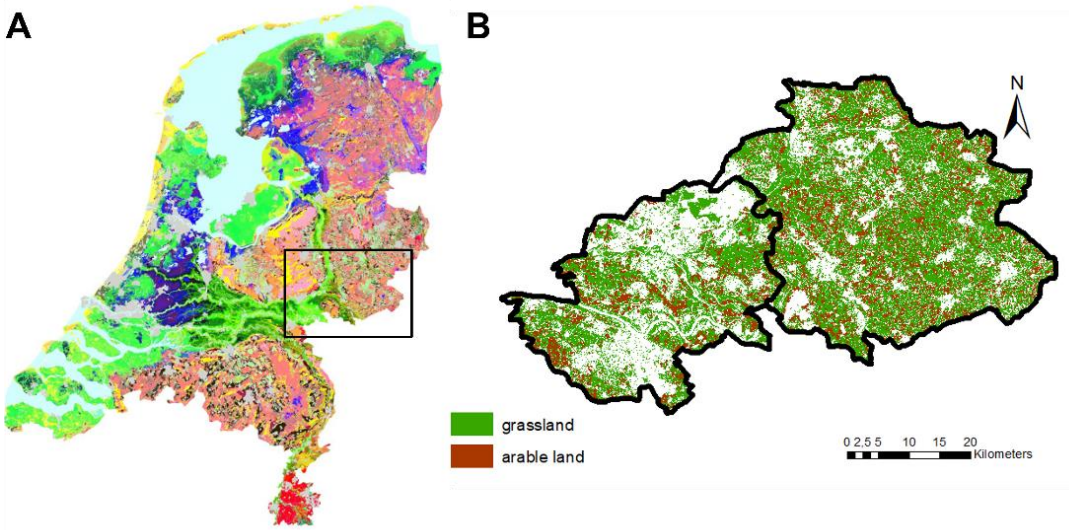


Figure 1-2:Soil map of the Netherlands (A), grassland and arable land (B).

The area currently suffers from the effects of climate change, especially longer drought spells causing water shortages, as well as more extreme rainfall events. This results in agricultural land that is sometimes too wet to cultivate or too dry to obtain stable yields. Soil compaction is another soil threat that goes hand in hand with the cultivation of wet soils with heavy machinery.

Many initiatives that stimulate the transition towards a sustainable region take place in the region (e.g., projects of the Platform Nature Inclusive Agriculture, Living Lab Soil Valley, projects of the Association Agricultural Landscape Achterhoek (VALA), Kunstmest Vrije Achterhoek (Chemical fertilizer free Achterhoek), Green Metropol Region Arnhem-Nijmegen).These projects and initiatives closely collaborate with stakeholders (e.g. farmers, policy makers, industry) to develop a common vision on the future of the region.

Table 1-1:Regional Information of Gelderland, Netherlands

Dominant land use:	Dairy farming
Secondary land use:	Arable farming
Climatic Zone:	Cfb = Temperate oceanic climate
Soil WRB classification:	Podzol, Fluvisol Anthrosol
Soil type:	Podzol (in Dutch: veldpodzol), Fluvisol (in Dutch: beekeerdgrond, poldervaaggrond), Anthrosol (in Dutch: eerdbodem)
Dominant topsoil texture:	Sand (in the higher regions), Clay (in the valleys)
Soil threat(s):	Too dry (Podzol, Anthrosol), Too wet (Fluvisol), Soil compaction (everywhere)
Representative regions:	The region Southeast Gelderland represents areas with intensive dairy farming like Fladers, Northwest Germany and Denmark, but also regions where intensive agriculture is taking place close to Natura2000 areas.

1.2 Stakeholder Interaction

The Figure 1-3 shows the different categories of stakeholders interacted during the soil needs assessment workshops and interviews in the Gelderland region. The workshop took place at a central location in the region on 25 April. Together with one of the stakeholders, SoilValley, we organised the workshop at the InnoFields terrain of Royal Eijkelkamp. At this terrain, innovations developed by e.g., Royal Eijkelkamp, can be demonstrated and tested, which was an extra trigger for stakeholders to join the workshop. The invitation was sent to 93 stakeholders, of which 26 attended the workshop in the end.

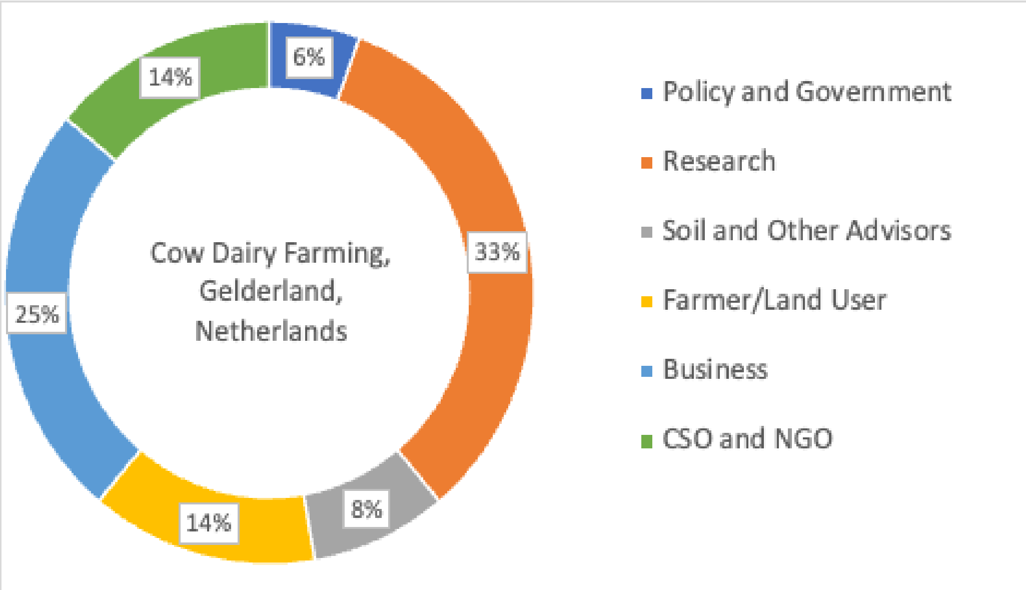


Figure 1-3: Stakeholder interaction in Gelderland, Netherlands

1.3 Soil Needs Assessment

1.3.1 Drivers

Biophysical drivers: Climate change is the biggest biophysical driver in the region. In recent years the region specifically suffered from extreme droughts, and extreme rainfall also occurs more regularly. As Achterhoek mainly consists of sandy soils, the area is already fairly prone to droughts. In addition, the Dutch water system is built to get rid of surface water as quickly as possible through ditches and canalized rivers. These two factors, in combination with longer and more intense periods of drought, lead to significant water shortages for the agricultural sector in this region.

Socio-economic drivers: To keep the farm profitable, intensification and specialization were necessary. Land consolidation has played an important role in the realization of this intensification and specialization. With this, landscape elements that harbor a large biodiversity disappeared, and the machinery used for land management became bigger and heavier. The focus was on producing large quantities of food that are affordable for everyone. egulations regarding the use of fertilizer have increased the export of manure. The abolition of derogation will have a negative impact on water quality. Also, other regulations can have a negative impact in combination with climate change. For example, regulations regarding the latest crop harvesting date and the latest sowing date of green manure can cause soil compaction when the land is too wet.

1.3.2 Pressures

Climate change is the largest pressure in the region. Especially over the last few years, land users and owners have become more aware of this. Droughts (especially in spring) cause insecure food production, and extreme rainfall events cause soil compaction or soil sealing. Decreased water quality, mainly due to large manure surpluses, is another pressure, as water quality should meet the (inter)national standards.

Another pressure that stems from the mentioned drivers is the increased use of heavy machinery on agricultural land. Additionally, due to the increase in monoculture, it is now very common to let fields lay barren for a while. This is done to decrease the chance of pests and diseases that can become present in areas where only a single crop is grown for consecutive years. Lastly, mainly due to socio-economic drivers (e.g., more industry, housing, increased attention for nature areas) and natural drivers there is an increase in water demand. This also puts pressure on the soil and influences soil management practices.

1.3.3 State

Soil compaction, soil sealing, and soil that is too dry or too wet are mentioned as the main current soil threats. Sensors and monitoring programs should create awareness of soil issues. According to a study conducted by Wageningen Plant Research and Wageningen Livestock Research, participants of the 'Bodem & Klimaat Netwerk Veehouderij' consider (sub)soil compaction and rooting as the most important problems to tackle (van Hal & Wagenaar, 2021). The monitoring programs should accelerate the sense of urgency to take the necessary actions. However, these actions are still not always taken by landowners or users. Stakeholders need to see the current (and alternative) state by demonstrating the decline in (soil) biodiversity and the effect of more climate-resilient management.

To aid the farmers in their transition to retaining more water and nutrients within their soil, many different small-scale initiatives and pilots have been started by means of different management techniques. These include the decrease in use of heavy machinery, incorporating flowers and herbs in the landscape, and using animal manure and compost instead of other (synthetic) fertilizers (van Hal et al., 2022).

1.3.4 Impact

The impact on the soil is mainly observed in terms of organic carbon and matter in the upper soil and compaction. The decrease in organic matter in the soil can be mainly attributed to the use of heavy machinery and plowing/tilling. This disrupts soil life and can cause soil sealing, which leads to run-off of (applied) nutrients. Secondly, soil compaction occurs in sandy soils (mainly Achterhoek) in the deeper layers of the soil, which means it is often not directly recognized as a problem. However, compaction also occurs in the upper layers of the soil in the area of Arnhem-Nijmegen, as the soil in this region generally contains more clay and is thus more prone to compaction.

The excessive use of fertilizers and pesticides has affected the quality of the water. Due to regulations, the water quality in the area improved. Yields became more insecure, especially in monocultures. More variation in crop and grass species makes the system more resilient to droughts. Also, flower or wood edges have a positive effect on water quality and biodiversity. However, all actions (except carbon sequestration) are currently still based on voluntary actions. Rewards for ecosystem services can stimulate sustainable land use.

1.3.5 Response

As a response to increased environmental pressure, many small-scale initiatives are introduced to stimulate sustainable agriculture. These may spark other innovative solutions by farmers and act as drivers themselves. In addition, the proof of concept of adopted techniques may also convince other farmers to practice management that is beneficial to soil health.

Extensive and/or nature-inclusive farming on the boundaries of nature areas can help decrease the environmental pressure on vulnerable nature areas. Nature and agriculture should (again) be more interwoven. Subsidies and policies should reward farmers for all measures that enhance ecosystem services, not only a single element, as is currently often done. Subsidies can help a farmer implement a measure, but in the end, the whole system needs to respond, including the market and consumers.

In addition, the short value chain was mentioned as one of the solutions towards a more sustainable region. However, this topic also caused much discussion, as this type of farming will perhaps only be profitable when a small group of farmers produce food for the short value chain.

1.4 Conclusions

In the last decades, intensive agriculture, especially dairy farming and arable agriculture, have become the most prominent land use types in South-East Gelderland. As the region mainly consists of sandy soils, the effects of climate change significantly impact water availability and soil health. Specifically, soil compaction in the subsoil of sandy soils is still an overlooked issue among landowners, whereas soil sealing in clayey soils is more well-known. To combat the effects of climate change and create a more resilient landscape, many small-scale initiatives have been started. These initiatives often focus on extensive, nature-inclusive management. The most common measures include the implementation of herbaceous grassland, using animal manure instead of synthetic fertilizer, and minimizing soil disturbing practices (e.g., tilling).

Furthermore, it is very uncertain how agricultural practices will develop in the coming years due to the political landscape. Many (inter)national regulations and policies may influence the manner in which agriculture might develop in the coming years. As the Netherlands is facing its next elections coming November, there is still a lot of uncertainty, especially regarding livestock farming. Countless factors and transitions will play a role, including ones that aren't elaborated upon here, such as the need for more housing, groundwater extraction from industry and drink water companies, the energy transition, or changes in consumption patterns. Although the first signs of a transition towards sustainable soil management are present, there is still a lot to be gained regarding regenerating the soil in Gelderland. Many farmers are still using a lot of heavy machinery, which degrades the soil, and the effectiveness of many measures highly depends on the time and effort of farmers as well as the skills that are required.

1.5 References

Fujita, Y., & Ros, G. (2021). *Locatie Specifiek Maatwerk voor Water- en Bodemkwaliteit; Deel 1. Een gebiedsanalyse van de Achterhoek.* Wageningen, Rapport1761.N.20.1, 36 pp.: Nutriënten Management Instituut BV.

Miedema, R. (1993). Afzettingen in Gelderland van een verwilderd, Laat-Weichselien Rijnsysteem: bodemvorming, eigenschappen en landgebruiksmogelijkheden. *Grondboor en Hamer 47*.

Rougoor, C., & van Well, E. (2016). *Landbouw en klimaatverandering in Gelderland.* Culemborg: CLM Onderzoek en Advies (CLM-922).

van Hal, O., & Wagenaar, J. (2021). *Bodem & Klimaat Netwerk Veehouderij - Rapportage 2020.* Wageningen: Louis Bolk Instituut.

van Hal, O., Wattel, E., & Wagenaar, J. (2022). *Bodem & Klimaat Netwerk Veehouderij. Tussenrapportage 2021.* Wageningen: Louis Bolk Instituut.

2 Sheep Agrosilvopastoral Farming:Sardegna, Italy

Matilde Schirru, Simone Mereu, Antonello Franca, Pasquale Arca, Enrico Vagnoni (National Research Council - CNR, Sassari, Italy)

2.1 Regional Information

Sardinia is an Italian island with approximately 24,000 km2 of surface and a Mediterranean climate characterized by mild winters and dry summers. The average annual temperature ranges from 11.6 °C to 18.0 °C, with the presence of eight phytoclimatic horizons mainly correlated with altitude (Canu et al., 2015). Rainfall ranges from 400 mm in the plains to over 1,200 mm in mountainous regions, with a highly variable distribution. Sardinia is warming on average by 0.4 °C per decade, with a gradient of increase from west (on average 0.035 °C/y) to east (on average 0.04 °C/y) as effects of climate change (Cipolla and Montaldo, 2022). The island's complex orographic features result from geological processes over time. Sardinia's geology includes Variscan metamorphic rocks, Cenozoic volcanism, and sedimentary deposits from fluvial and marine activity. Consequently, the island's soils vary depending on their parent material, categorized into sedimentary, crystalline, and effusive rock-derived soils. Approximately 46% of the island faces a risk of desertification, while nearly 40% is considered fragile. Climate change poses additional challenges, including soil salinization due to seawater intrusion, erosion, and increased wildfire risks. These threats require careful consideration in adaptation and mitigation strategies. Sardinia's agricultural landscape is traditionally dominated by dairy sheep farming, with different degrees of farming intensity according to the island's diverse pedo-climatic conditions (intensive production systems in lowlands and agropastoral systems in mountainous areas).

This study focuses on the Gennargentu Massif in Central Sardinia, an area characterized by acidic soils derived from granitic rocks. In particular, we consider the upper part of the Tirso Valley watershed Figure 2-1 .Land use includes pastures, agroforestry, and cork oak woodlands. Land use changes, such as the conversion of maquis into pastures, have led to soil organic carbon loss, and the region also grapples with land abandonment and fire risk (Table 2-1).

Figure 2-1: Map of the primary soil's parental rocks in Sardina

Table 2-1: Regional information Tirso valley

Dominant land use:	Less than one third of the Tirso valley (104,536 ha) is characterized by silvopastoral land uses, mainly based on dairy sheep farming systems, with a gradient of heterogeneous land use ranging from forest (73,745 ha) to arable lands in the low valley, (more than 75,700 ha)
Secondary land use:	Shrublands characterized by Mediterranean maquis, permanent pastures, urban areas
Climatic Zone:	Mediterranean, with a 3 months drought in Summer and rainfall in Autumn and Spring
Soil WRB classification:	Mainly rock outcrop, lithic xerorthents
Soil type:	clay accumulation, shallow water table and salt accumulation shallow, moderately fertile and with relatively high amounts of organic matter poor fertility, high erosion risk (slope), characterized by stoniness and rockiness shallow and acidic soils
Dominant topsoil texture:	Mainly from sandy to sandy-argillaceous soils
Soil threat(s):	Erosion (water), desertification.
Representative regions:	ES61 (Andalusia), ES42 (Castilla la Mancha), ES43 (Extremadura) / EL65 (Peloponnese), EL43 (Crete), EL62 (Ionian Islands) / ITF4 (Apulia), ITF6 (Calabria), ITF2 (Molise) / CY (Cyprus). Other olive-growing Mediterranean regions (Italy, Greece, Cyprus, Croatia, etc.).

2.2 Stakeholders Interaction

The Figure 2-2shows the different categories of stakeholders interacted during the soil needs assessment workshops and interviews in the Sardegna region. The PREPSOIL Workshop was designed in order to characterize perception and co-create a common vision of participants concerning Soil health in Sardegna, linked to agrosilvopastoral systems, facing experience and scientific evidence. The Workshop was held on the 23 June 2023, at the Museo dell'Asfodelo (Asphodelus ramosus) di Ollolai, Province of Nuoro, Sardinia (Italy). Ollolai is a village of 1700 people located in the historical homonym subregion of Barbagia, an inland and mountainous area in central Sardegna, upper valley of the Tirso river.

The choice to manage PREPSOIL Workshop in this territory is mainly linked to its centrality within the study area, but also to the agro-pastoral context of reference and further issues that characterize this community, emblematic for the majority of the inland context. The strong depopulation phenomenon, due to low births and abandonment in favor of other areas, encouraged local policies in recent years to attract new residents in the area prioritizing those that would bring new agricultural engagements or protect environmental and cultural resources. Among these elements is the precious resource of natural soil capital, on whose capacity the performance of human activities depends, and vice versa, the effects on the capacity to preserve and/or improve soil characteristics depend on the proper management of the latter.

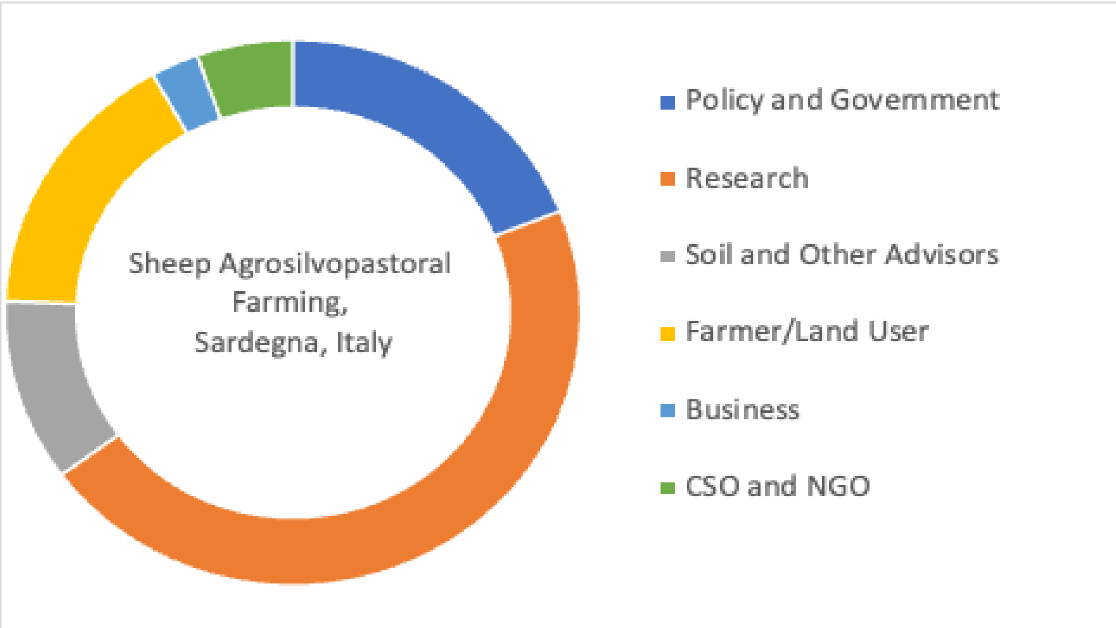


Figure 2-2: Stakeholder interaction in Sardegna, Italy

2.3 Soil Needs Assessment

2.3.1 Drivers

Biophysical drivers: Generally, the combination of landscape morphology and Mediterranean climate originates soils that are fragile and extremely sensitive to degradation under any land use change that does not properly take into account the soil's qualities and limitations (Vacca et al., 2002). It is noteworthy that Sardinian soils are prone to erosion, particularly those in class I of land capability that represent about 11.3% of the Sardinia area deemed at risk of erosion (INEA, 2010). The Soil Carbon Content (SCC) is low on average (1.68%), but it is particularly low in the lowland arable soils submitted to frequent tillage (1.28%) (PSR Sardinia 2014-2020, http://www.regione.sardegna.it/speciali/programmasvilupporurale/psr-201420 20). Grazing management and permanent vegetation that characterize the Tirso Valley (permanent secondary grassland, rangeland, and woodland) are the main causes affecting the potential of soil C sequestration (Refer Figure 2-3 for an example of grazing). Adequate agropastoral practices may be effective in increasing soil C sequestration, especially in extensive livestock farming systems where permanent secondary grasslands play an important role as C sinks (Bernues, 2017; Hopkins and Del Prado, 2007).

Permanent vegetation (pastures, silvopastures, rangelands) improves soil C stock with respect to arable crops due to the higher stability of C returning to the soil and to an increased residence time of C in the absence of soil tillage (Soussana et al., 2004). Regulating grazing management can improve soil C sequestration both under overgrazing and undergrazing conditions (Vigan et al., 2017). Grazing management may be a relevant mitigation strategy when adopting specific grazing management solutions, such as a rapid rotation of pasture grazing to limit the digestibility decay related to herbage mass accumulation or a part-time afternoon grazing that may enhance ruminant intake and performance through a more efficient rumen N incorporation (Molle et al., 2016). Climate change, which has been identified as a main biophysical driver within Sardinia's soil needs assessment, is very likely to cause soil losses, losses of soil biodiversity and fertility, and eventually trigger or accelerate desertification. Moreover, the risks of desertification are exacerbated by disturbances, from the cyclic locusts' infestations (Klein et al., 2022) to the development of extreme wildfires, which, coupled with the severe heat waves and drought conditions, increase fast soil erosion dynamics (Salis et al., 2019). In brief, climate change leads to increased aridity, prolonged drought periods, and extreme precipitation events. Such drivers, if combined with unmanaged conditions due to grazing exclusion, often lead to increased soil erosion.

Another relevant biophysical driver is the geographical isolation of the upper part of the Tirso Valley. Both the rugged orographic structure and low public investments in communication infrastructures collocate this area in a pronounced marginality among the whole Sardinian landscape. In fact, hills and mountains prevail, and the proportion of farms with stock higher than 500 ewes represents only 10% of the total (lower numbers than those found in other areas of Sardinia). Land devoted to crops on irrigated arable land represents only 10.6% of the total area, while non-irrigated crops, such as forage, account for 6.5%.

The soil and environmental indicators that we could take into account to evaluate soil resilience could include: i) Land capability, ii) Climate change, iii) Salinization, iv) Desertification. Land capability classification (USDA), through the main characteristics of soil (tessiture, permeability, pH, etc.), could be a useful proxy of soil's suitability for agricultural, forestry, grassland, and pasture land uses. Although this classification is in general accurate, Sardinia's land capability is not well discriminated, due to the low scale of detail (1:350k). For instance, the soils of the southern and northern lowland or moderately sloped hills of the island often fall into the same land capability class (generally classes 2 and 4). Instead, the simplified 3-class clustering of Sardinian soils has been proven sufficiently adequate to explain the variation occurring in natural vegetation between macro-areas (e.g., the CORINE land cover map, http://www.sinanet.isprambiente.it); Climate change factors, in combination with other management factors such as intensive cultivation or sudden and unsupervised land abandonment (no cultivations and no grazing), can have catastrophic effects on the ecosystems, not only towards soil conservation but also on the whole biotic component present. Salinization is already a problem in some areas of Sardinia due to the intrusion of sea water into water tables adjacent to the coastline (INEA, 2010; Puddu et al., 2008) and should be taken into account for low-altitude areas. Due to pedology, land uses, and climate, approximately 46% of the island faces a risk of desertification, while nearly 40% is considered fragile (PSR Sardinia 2014–2020).

Figure 2-3: Asphodelus ramosus prairies in Sardinia's overgrazed natural pastures.

Socioeconomic drivers: Due to poor land capability, which prevents the use of Sardinian soils as agricultural land, Sardinia is traditionally devoted to livestock production, in particular dairy sheep raising. Traditional pastoralism shaped the culture and landscape of the island over the centuries, and it coexists nowadays with industrialized dairy sheep production systems. In particular, sheep production has become the basis of the rural economy in Sardinia since the second half of the 19th century, when the first cheese factories were settled by companies based in the Latium region of Italy, starting out the production of what is still the main sheep dairy product in Sardinia and Italy: the Pecorino Romano Protected Designation of Origin (PDO) cheese. Since then, sheep production has undergone a manifold development, with a dramatic rise in milk yield per ewe and per farm, an improvement in milk quality and animal welfare, an upgrade of dairy plant technologies, and cheese marketing. Sardinia is actually a world leader in the sheep cheese sector, with more than 10.000 sheep farms, around 3 million sheep heads that produce about 320 kt of milk per year (13% of the total European production), and 50 kt of sheep cheese per year produced on 50 dairy factories (Atzori et al., 2022). Sardinia is the main region for sheep cheese exports in Europe, thanks to Pecorino PDO, which represents 50% of total European sheep cheese PDO production. Other PDO dairy sheep cheeses, such as Fiore Sardo, exceed not more than 2% of the total dairy production. However, there are still facets of the sector that remain tightly bound to the milk and cheese price fluctuations—as a result of global market equilibrium and local cheese stock and management—on the one hand and to the public incentives of the Common Agricultural Policy (CAP)—that represent about 20% of the Sardinian sheep farms income on the other hand (Pulina et al., 2018). This, in combination with structural problems along the supply chain and radical policy changes (e.g., the European Green Deal), imposes efficiency improvements via modern technologies and eco-innovations on the whole sector. Indeed, the sector has tremendous potential for food and unmarketable public goods, such as open landscapes, biodiversity, and social cohesion, and regulating ecosystem services, such as soil carbon sequestration from pastures, biodiversity, maintenance of cultural landscapes, and fire prevention (Atzori et al., 2022). Focusing on the study area, we can split the socio-economic drivers into two main groups as follows.

i) Direct anthropogenic factors, which include:

- Land-use change (in the past conversion from woodland to pasture lands, followed more recently by intensification of the sheep farming system and current land abandonment);
- Declining and aging population;
- Limited access to credit by agro-livestock farms;
- Limited access to technical assistance (knowledge transfer chain gap);
- Lack of alternative economic activities;
- Poor infrastructure (roads, public transport, internet).

ii) Socio-economic factors, which include:

- Fluctuations in sheep milk prices due to a structural feature of the sheep industry;
- Cultural and social context (solidarity vs. individualism);
- CAP and public policies (e.g. subsidies per head);
- Public policies against the decline of the local population (low-cost housing, slow living, etc.);
- Raising awareness of the importance of soil;
- Increasing knowledge about soil science (e.g. microbial community, impacts of management and/or vegetation);
- Common land for grazing (poorly regulated land uses).

Within the participatory activities, the factor that was recognized as the most crucial and severe among all these drivers was the depopulation phenomenon (refer Figure 2-4 for an example of participation in the workshops). Due to other economic attractions, different from traditional agriculture, depopulation is causing the abandonment of inner areas as well as rural land and their related soils. Low birth rates and population aging, coupled with the low income per capita of the remaining people, represent the main threats to the abandonment of rural soils.

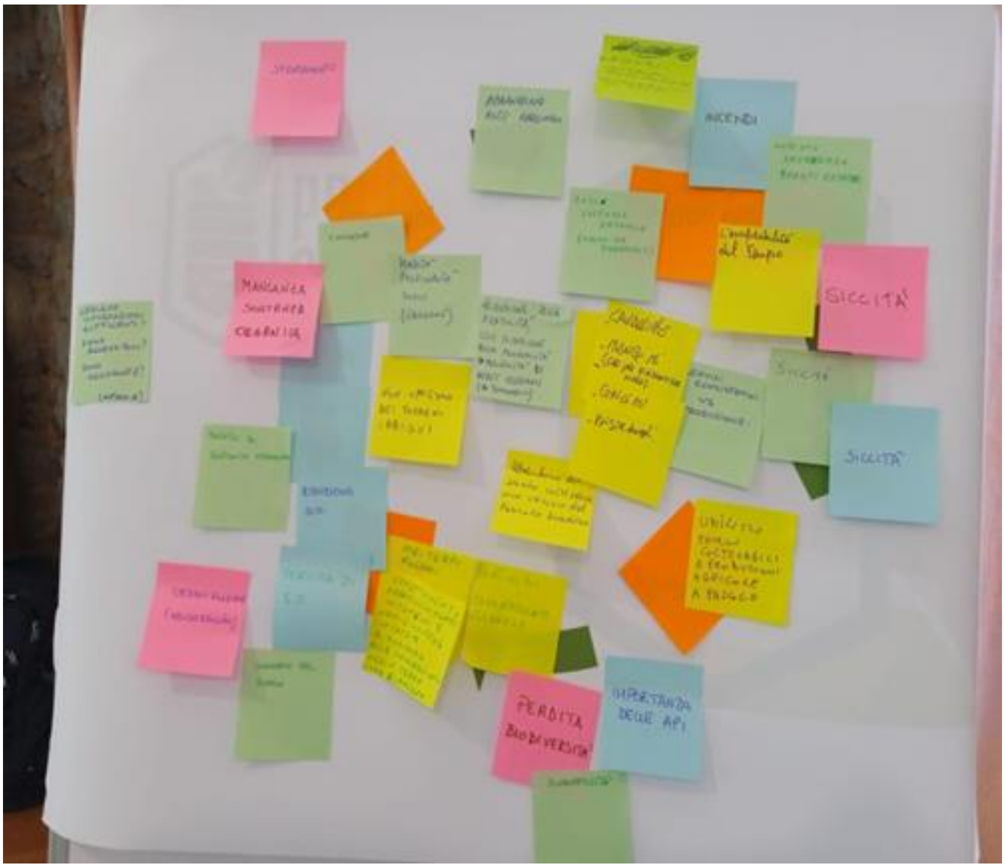


Figure 2-4:Emerging topics clustering keywords from the participants' point of view

2.3.2 Pressures

The main pressures in the system linked to the above-mentioned drivers and that represent crucial targets for soil health improvement in the future can be referred to as overgrazing and overexploitation of the soil. During the last decades, the intensification of the dairy sheep farming system has led farmers to strongly rely on mechanical operations for fodder cultivation purposes, even in marginal areas. The objective of increasing the annual forage crop was brought to the wide and undiscriminated use of intensive mechanization (plowing, tillering) even inside silvopastoral shrublands, apparently not agronomically indicated for fodder cultivation due to stony and steep slopes. Also, a relevant land use change in this marginal area occurred after 1976, when the "improvement of pastures" was promoted with incentives that were often used for the clearing of shrublands, mostly Mediterranean maquis, to convert them into pastures. This technique was erroneously interpreted as permission for utilizing high-input agronomic solutions, such as shrub clearing by fire or tillering, with dramatic consequences for soil properties. Such conversion often occurred over steep slopes too, and it has been estimated that the land use change from maquis to pasture approximately entails a loss of SOC between 20% and 30% (Zucca et al., 2010). Moreover, the increase in sheep milk demand, which follows the cyclical trend of the Pecorino Romano cheese price, encouraged the increase of the Sardinian sheep stock (instead of ewes' productivity improvement), exacerbating the overgrazing and overexploitation phenomena (Atzori et al., 2022).

Overgrazing and overexploitation of soils are strongly correlated to both soil compaction and biodiversity loss (alpha and gamma). On the other hand, high flock density is correlated with an imbalance in the fodder/feed supply chain due to the import of feed stocks and the limited farm feed self-sufficiency. As mentioned above, regulating stocking rates and grazing pressure may, on the contrary, represent an effective mitigation strategy.

Another relevant pressure is represented by the extreme wildfires that are soil erosion multipliers. The effect of large or extreme fires on the soil system depends on several factors, such as fire intensity and duration, litter quality and thickness, physical, chemical, and biological characteristics of the soil, climatic conditions, topography, and landscape heterogeneity. As a result of the passage of fire, the traversed areas are subject to a number of important physical alterations that result in: i) reduction of water interception due to the loss (partial or complete) of vegetation cover and the reduction of water infiltration rate; ii) alteration of hydraulic properties of soils; iii) the creation of ash and consequent water repellency phenomena. Such alterations can result in increased surface water runoff and erosion. In addition, large and severe fires are also a potential threat to watershed conditions and can have multiple effects on hydrological processes, including changes in flow regimes, flood frequency, erosion, and debris flows. These effects are due to reduced soil hydraulic conductivity and decreased stability of soil aggregates, but it is necessary to consider that the impact of fire on the hydrological and geomorphological compartment depends on multiple interrelated factors, including weather conditions after an event. For example, intense thunderstorms following fires can increase the risk of extensive flooding and high sediment loads. Several studies have highlighted how high rates of post-fire soil erosion, in the short term, are often linked to extreme weather conditions, in particular intense rainfall (Robichaud et al., 2006). A very important aspect to consider is related to the dynamics of vegetation recovery: in the Mediterranean environment, vegetation tends to gradually return to values typical of pre-fire conditions within 5 years of disturbance. However, several studies have noted that erosional responses in fire-affected areas last less than 7 years and depend not only on vegetation recovery but also on post-fire weather conditions, sediment availability, morphology, and fire severity (Salis et al., 2022). Notably, the frequency of so-called megafires is increasing with climate change.

Hereafter the kind of pressure identified within the stakeholders engagement are summarized:

- Overgrazing and over-exploitation of the soil;
- Soil compaction;
- Loss of biodiversity (alpha and gamma);
- High flock density (importation of feed stocks and imbalance in the fodder/feed supply chain);
- Extreme wildfires.

2.3.3 State

The Sardinian dairy sheep production systems, outlined by Molle et al. (2017) within the European SheepToShip LIFE project (http://www.sheeptoship.eu), can be clustered into two main groups of farms according to geo-pedological conditions and average annual rainfall: (i) Central Sardinia farms, characterized by hilly and mountainous morphology, effusive and granitic rocks, and average annual rainfall >800 mm; (ii) Northern and Southern Sardinia farms, characterized by plain and hilly morphology, sedimentary soils, and average annual rainfall <800 mm. As demonstrated by research activities conducted in SheepToShip LIFE (Arca et al., 2021; Atzori et al., 2022; Vagnoni et al., 2023), the different geo-pedological conditions influence the structure and features of both farm groups. The reasonable soil depth of the sedimentary soils of North and South Sardinia allows farms to manage almost all of their agricultural area with arable crops (more than 75%), while a lesser extent is devoted to natural pasture. Of course, arable land management involves a significant use of agricultural inputs, such as mechanical soil operations, nitrogen fertilizers, and irrigation water, to maximize on-farm forage production. Instead, most of the agricultural area of Central Sardinia (in which the study area is included) has shallow soils and significant unevenly distributed rockiness that are reflected by low fertility and production potential, and it is thus occupied by natural pasture directly consumed by sheep grazing. In this case, the low input management required by natural permanent grasslands and the limited surface area occupied by arable crops result in a lower use of nitrogen fertilizer and irrigation water, which also implies a lower feed-sufficiency level.

The potential vegetation of the study area would be oak woodlands (*Quercus ilex* and *Quercus pubescens). H*owever, human activities have substantially shaped the landscape, promoting *Quercus suber* for cork production, lowering the tree density (agroforestry), and using (15%) of the territory for the cultivation of feed crops. At present, the land use for agroforestry is very wide (29%), and the dairy sheep farming system accounts for a major part (25%) of the whole Sardinia Island. Woodlands based on cork and bushland are often grazed in the mountain areas of Sardinia as well as in other Mediterranean areas, covering 28% of the case study area. The broad-leaved forests account for 36%, cork oak forests account for 17%, and maquis and garrigues take up approximately 18% of the land share, while urban land use is low with very little urban sprawling. Extensive use of deep and/or superficial plowing is a concern for soil quality and alfa biodiversity; however, as with other marginal areas in the region, the study area suffers from land abandonment with cascading effects on gamma biodiversity and fire risk, as well as intensified soil erosion until a natural cover is re-established.

The problems’s statement of the study area as defined by the participative activities should be summarized as follows:

Biophysical situation

- Fragile and infertile soils (rocky, shallow);
- Past soil degradation;
- Low productivity;
- Aridity;
- Low soil fertility;
- Orography (few plains).

Socioeconomic situation

- Migration of young population to more attractive areas;
- Lack of or limited generational turnover in agriculture;

- Low per capita income.

2.3.4 Impacts

The heterogeneity of technical and production factors that characterize the Sardinian sheep sector results in different environmental performances between sheep farming systems. A Life Cycle Assessment (LCA) study performed by Vagnoni et al. (2023) in a selected sample of the above-mentioned sheep farming groups showed that Central Sardinia farms resulted most impacting when environmental impacts were referred to a mass-based functional unit (1 kg of normalized milk) and less impacting when the area-based functional unit was considered (1 ha of utilized agricultural area). It is important to highlight that among the 16 impact categories considered in this LCA study, land use resulted among the main relevant impact categories (those that cumulatively contributed at least 80% of the total environmental impact, excluding toxicity-related impact categories), with a contribution of 24% (after climate change with 25%, followed by water scarcity, and mineral and metal use). Specifically, the land use impact was due to on-farm feed production (which contributed to the total land use score by 76% on average) and, secondly, to purchased feed (14% of the contribution). Moreover, Central Sardinia farms showed a higher soil carbon sequestration potential than Northern and Southern ones: 1129 vs. 872 kg CO_2 per ha of utilized agricultural area, respectively.

With regard to the stakeholder engagement activities, the following impacts (correlating with the pressure items previously highlighted) were identified:

- Loss of carbon stocks;
- Loss of biodiversity;
- Decline in water quality (downstream);
- Increased fire risk;
- Reduction in fodder production;
- Loss of soil resulting in reduced soil depth (5 cm lost since 1980).

2.3.5 Response

Regarding depopulation and the correlated problem of abandonment of rural soils, maintaining pastoralism might then be considered an effective tool, especially for maintaining soil and landscape qualitative traits. Moreover, in rural areas where pastoral land use is still an important socio-economic driver, pastoralism represents a milestone for wildfires' prevention. In particular, fire risk is generally maintained under control by two main factors: the consumption of fuel biomass by grazers and the presidium of the territories by shepherds and pastoralists. In a study carried out in Sardinia in a grazed woodland area where grazing exclusion was simulated, the risk of fire propagation was estimated to increase by about 70% in the ungrazed scenario. Moreover, the presence of a pastoral community is for sure an important support in protecting the fire-prone area, according to the authorities responsible for civil protection and firefighters.

The debate on viable solutions to support the future of pastoralism in the Mediterranean rural areas is wide and oriented towards initiatives that regard both policies and socio-economic challenges:

1. Recognizing the environmental role of pastoralism through a tailored and adequate policy of agro-environmental measures in the framework of the Rural Development Plan.
2. Evaluation and valorisation of ecosystem services (comprising regulating services for soils, such as soil C sequestration and soil protection from erosion) provided by pastoral systems, both on private and public lands.
3. Valorization of pastoral product quality: translate high-quality products into adequate profitability through a re-thought market appreciation.
4. Pastoral productions and sustainability: rethinking the concept of low production efficiency of extensive livestock systems towards a new narrative based on scientific data (LCA approach) that promotes the strength and efficacy of pastoral systems for mitigating the effect of climate change through the range of ecosystem services they provide, from fire prevention to carbon sequestration, from biodiversity enrichment to cultural heritage.

Hereafter are reported the potential solutions identified by the soil's experts interviewed:

i) A proper land and soil characterization in order to build knowledge of the current and future state and share the collected soil data with all the soil's stakeholders and/or scientists and consultants.
ii) To design training days on soil protection for communities. Each territory has different peculiarities, and local citizens and society should be informed in a targeted manner about the solutions to be applied in their context. Not general information but focusing on the local context.
iii) Chance of having rapid access to credit for soil restoration activities by local communities, e.g., for post-fire restoration strategies.
iv) Improving pastures with minimal or no tillage and the use of self-seeding of grassland species with high pastoral values, with a special focus on legume species. Estimating animal load in relation to seasonal forage availability.

v) Encouraging the regrowth and development of potential vegetation in unsuitable soils for grazing, e.g., steep, rocky, very degraded soils (high slopes). This could act in strong synergy with the EU objective of rewilding 10% of EU territory and guaranteeing that the rewilding areas are correctly identified.

vi) It would be desirable to tailor local community-level incentive policies to support and maintain agricultural activities in marginal areas.

vii) The role of the forest components in the performance of agro-livestock farms and the provision of ecosystem services could be emphasized. If we consider the reduction of carbon sequestration, biodiversity, and regulation of the hydrological cycle as a consequence of the non-conservation (productivity in a global sense) of agroforestry systems, the solutions could be: a) Tailor-made or at least non-contradictory rural development strategies (e.g., forestry laws contradicting RDP measures); b) quantification of ecosystem services and an increase in knowledge of the complex relationships between management systems and ecosystem service provision; c) an increase in the economic sustainability of agroforestry farms (e.g., product diversification, PES, etc.). Solutions should aim at restoring the soil organic carbon sink, restoring and enhancing biodiversity, and improving the regulation of waters.

viii) Overgrazing should be limited; technical support by the extension service for widening the innovative use of rotational grazing techniques (adaptive grazing management, i.e.) should be guaranteed.

ix) Soil fertility can be improved through the use of organic soil improvers (perhaps derived from waste biomass produced on the farm).

x) Enhancing technical advice, such as from external service providers, for farmers to mainstream the above solutions.

2.4 Conclusions

The suggestions and challenges raised from both Workshop and experts in-depth interview should be systematized and schematized in the following structuring evolutionary strategies and win-win solutions:

- To build and spread knowledge concerning Soil's Health, gathering and sharing data collected in order to build awareness, improve local strategies concerning soil management dealing with soil conservation/improvements goals, by farmers and rural communities.
- Encourage young people to participate in a new and multifunctional dairy sheep farming, ensure training on sustainable farming (environmentally, socially and economically) and allow easier access to credit in order to empower their agribusiness, related agrobusiness culture and entrepreneurs skills as capacity building goals.

- To promote eco innovation science-based solutions, such as the use of cover crops from arable land to permanent pastures or just improving natural ones in agroforestry systems. This could enhance soil health and soil biomass production for grazing/feeding animals. It could also contribute to halt the loss of biodiversity and ecosystem services, or even enhance them, meanwhile reducing dependence from external forages by farmers, and of course, profitability.
- As a consequence, enhancing the profitability of agricultural products could ameliorate the dignity of such complex work for farmers especially shepherds in marginal areas. In fact at farm level, a lower dependence from external farming inputs (e.g. for fodder) could represent the major real economic convenience for the production, scientific results say. This could be achieved by adopting a few tricks which would enhance soil health as well its capacity to offer good and increased pasture resources, and by reducing uncertainty of volatile prices for forages, fodders and fossil fuels for managing permanent crops as permanent or improved pastures.
- The unmanaged abandonment of agricultural land leads to an uncontrolled increase of biomass, with an ideal vertical and spatial distribution for fire propagation and intensity. Furthermore, land abandonment favors the dispersal of plant diseases and pest infestations further affecting soils and landscapes and the provision of ecosystem services. Agroforestry management could represent a good compromise in optimizing silvopastoral lands and associated ecosystem services, building resilient systems towards the uncertainties and often extreme conditions due to climate change phenomena.
- Recognizing new roles and changing narratives of pastoralism in common imaginaries towards the identity of a businessman's sector made by experts in sustainable management of land, landscape and ecosystem services stewards, which actively work to maintain it for the whole public benefit.

Depopulation and abandonment could represent the main bottlenecks for implementing those strategies that aim at the survival and attractiveness of these areas, promoting the improvement and conservation of related agrosilvopastoral soils, as well as boosting awareness concerning Soil Health and its proper management at the local level. It seems that it is not possible to care for Soil Health without allowing local communities in rural areas to have a good quality of life, instruction, knowledge, awareness of complex agrosilvopastoral issues, and profitability for farming activities. Long-term learning in agricultural, financial, and entrepreneurial fields could give a chance to farmers and potential farmers (such as young ones) in inland areas of Sardinia, especially in the upper part of the Tirso Valley.

2.5 References

Arca P, Vagnoni E, Duce P, Franca A, 2021. How does soil carbon sequestration affect greenhouse gas emissions from a sheep farming system? Results of a life cycle assessment case study. Ital. J. Agron. doi: 10.4081/ija.2021.1789.

Atzori AS, Bayer L, Molle G, Franca A, Arca P, Vannini M, Cocco G, Usai D, Duce P, Vagnoni E, 2022. Sustainability in the Sardinian sheep sector: A systems perspective, from good practices to policy. Integrated Environmental Assessment and Management, 18:5, 1187-1198.

Bernués A., Rodríguez-Ortega T., Olaizola A.M., Ripoll-Bosch R, 2017. "Evaluating ecosystem services and disservices of livestock agroecosystems for targeted policy design and management." In: Grassland resources for extensive farming systems in marginal lands: major drivers and future scenarios, Proc. of the 19th Symposium of European Grassland Federation, Alghero, Italy 7-10 May 2017 (Eds. C. Porqueddu, A. Franca, G. Lombardi, G. Molle, G. Peratoner, A. Hopkins), 259-268.

Canu S, Rosati L, Fiori M, Motroni A, Filigheddu R, Farris E, 2015. Bioclimate map of Sardinia (Italy), Journal of Maps 11:5, 711-718.

Cipolla SS, Montaldo N. On the Impacts of Historical and Future Climate Changes to the Sustainability of the Main Sardinian Forests. *Remote Sens.* 2022, *14*, 4893. https://doi.org/10.3390/rs14194893

Klein I, Cocco A, Uereyen S, Mannu R, Floris I, Oppelt N, Kuenzer C, Outbreak of Moroccan Locust in Sardinia (Italy): A Remote Sensing Perspective. Remote Sens. 2022, 14, 6050. https://doi.org/10.3390/rs14236050

INEA, 2010. Valutazione del rischio di salinizzazione dei suoli e di intrusione marina nelle aree costiere delle regioni Meridionali in relazione agli usi irrigui. R. Napoli (ed.). INEA, pp. 232.

Molle G, Decandia M, Sanna L, Vagnoni E, Pintus G, Duce P, Franca A, Manca A, Usai D, Atzori SA, 2017. Report of the characterization of Sardinian dairy sheep production systems. Available at: http://www.sheeptoship.eu/images/Report/A.1.3_Report%20char.%20Sard.%20pr.%20systems.pdf

Molle, G., Decandia, M., Giovanetti, V., Manca, C., Acciaro, M., Epifani, G., Salis, L., Cabiddu, A., Sitzia, M.,Cannas, A., 2016. "Grazing behaviour, intake and performance of dairy ewes with restricted access time to berseem clover (Trifolium alexandrinum L.) pasture." Grass Forage Science doi:10.1111/gfs.12228

Puddu R, Fanni S, Loddo S, Manca D, 2008. La salinizzazione dei suoli nelle piane agricole della Sardegna. Distribuzione, intensità e valutazione del rischio. Pubblicazione AGRIS, 80 pagg., aprile 2008, cod. ISBN 978-88-903404-1-3.

Pulina G, Milán MJ, Lavín MP, Theodoridis A, Morin E, Capote J, Thomas DL, Francesconi, AHD, Caja G, 2018. Invited review: Current production trends, farm structures, and economics of the dairy sheep and goat sectors. Journal of Dairy Science, 101(8), 6715–6729. doi:/10.3168/jds.2017-14015

Puxeddu M, Pintus A, Pulina G, 2008. I Meriagos: il confine tra prateria e foresta. Available at: https://www.sardegnaagricoltura.it/documenti/14_43_20081014112126.pdf

Robichaud, P.R., Elliot, W.J., Pierson, F.B., Hall, D.E., Moffet, C.A. 2006. Erosion Risk Management Tool (ERMiT), Version 2006.01.18. [Online: http://forest.moscowfsl.wsu.edu/fswepp/] US Department of Agriculture

Salis M, Del Giudice L, Robichaud P R, Ager A, Canu A, Duce P, Pellizzaro G, Ventura A, Alcasena-Urdiroz F, Spano D, Arca B (2019) Coupling wildfire spread and erosion models to quantify post-fire erosion before and after fuel treatments. International Journal of Wildland Fire 28, 687-703.

Salis M, Del Giudice L., Jahdi R, Alcasena-Urdiroz F, Scarpa C, Pellizzaro G, Bacciu V, Schirru M, Ventura A, Casula M, 2022. Spatial Patterns and Intensity of Land Abandonment Drive Wildfire Hazard and Likelihood in Mediterranean Agropastoral Areas. Land 11: 19-42. https://doi.org/10.3390/land11111942

Vagnoni E, Arca P, Duce P, Cossu D, Decandia M, Molle G, Serra G, , Sau P, Lunesu M, Porqueddu C, Atzori AS, Franca A, 2023. Looking for the ecological transition of Mediterranean small ruminant systems. Characterization and main drivers of environmental performance in the Sardinia sheep sector. [Manuscript submitted for publication].

Vigan A., Lasseur J., Benoit M., Mouillot F., Eugène M., Mansard L., Vigne M., Lecomte P., Dutilly C., 2017. « Evaluating livestock mobility as a strategy for climate change mitigation: Combining models to address the specificities of pastoral systems.” Agriculture, Ecosystems & Environment 242: 89-101

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. doi:10.1016/j.catena.2010.07.003

3 Irrigated Arable Farming: Communitat Valenciana, Spain

Artemi Cerdà; Co-authors: Francisco Escriva, Saskia Keesstra

3.1 Regional Information

In the Valencia region, the traditional flood irrigation was fed with natural karstic springs, as in many regions around the Mediterranean) where limestones are rocks widely distributed. In the La Ribera district, the river Xúquer allowed a large flood irrigation system that is millennia old. This sustainable system is being changed into drip irrigated areas recently. Drip irrigation brings a large industrialization of agriculture with it and promotes the use of chemical fertilizers, and herbicides. The agriculture terraces are destroyed to facilitate the use of tractors and mechanize the labour. To avoid weeds, large amounts of herbicides are applied. Other agrochemicals are used to control the pests. This system is very productive in terms of the amount of citrus that can be produced but has several negative impacts, such as the loss of biodiversity, which affect the soil biota and larger fauna such as rodents and birds as well as above-ground insects. The offside waterbodies are also affected. Secondly, the social structure of the community is lost. Thirdly, the removed irrigation channels cannot provide their drainage function in the case of large amounts of precipitation. Lastly, the landscape in terms of cultural heritage and attractiveness for agri-tourism deteriorates.

The region of Central District of Valencia region is located at the southern part of Valencia Province (Figure 3-1). The districts of La Costera, La Ribera, and l'Horta Sud, in any case, include Lake Albufera with his paddy fields too. This area moved from 300 mm year^{-1} inland to 700 mm year^{-1} in the coastal lands, and from rainfed to paddy fields (refer Table 3-1 for additional information). The transect from Font de la Figuera to Cullera shows most of the Mediterranean landscapes from the strict rainfed vineyards, almonds, olives, and cereals to the flood irrigation paddy fields. In between we have flood and drip irrigation on fruit and citrus, olives, and vineyards. This transect of 100 Km can be seen as three zones:

1. The drylands (Els Alforins, with olive and vineyards)
2. The irrigated agricultural land (Montesa, with drip irrigation)
3. Floods irrigate land (L'Énova, flow irrigation)
4. The sedimentation/lake area (Sueca, with paddy fields)

The potential floristic composition of the Canyoles River Watershed is a cover of oaks (*Quercus ilex*). However, the human impact transformed the original woodland into a macchia that covered most of the mountains and that was used as a pastureland for millennia. The macchia (*Pistacia lentiscus, Juniperus oxicedrus, Quercus coccifera*) was degraded due to the overgrazing along the 19th century and a degraded shrubland (*Thymus vulgaris, Cistus albidus, Rosmarinus officinalis*) covered the land, and in some areas, the degradation resulted in a very low cover of plants, almost a desert of white rocks. The abandonment in the 20^{th} century resulted in the recovery of the macchia vegetation and the afforestation with *Pinus halepensis*. In the 21^{st} century, forest fires are recurrent and due to the successful recovery of the vegetation the risk of forest fire is very high. Fire is a key factor in the evolution of the vegetation in the Canyoles River Watershed.

Table 3-1:Regional Information of Comunitat Valenciana, Spain

Dominant land use:	Irrigated agriculture and adjacent drylands cropping. Traditional flood irrigation is being transformed into drip irrigation and also rainfed is moving to drip irrigation that is increasing the production.
Secondary land use:	Peri-urban and nature. Rangelands and forest of Pinus halepensis.
Climatic Zone:	Mediterranean with a 3 months drought in Summer and rainfall in Autumn and Spring
Soil WRB classification:	Aridisoles and Entisoles
Soil type:	Soils on calcareous silts with low carbon content.
Dominant topsoil texture:	loamy clays and sandy clays (depending on geology type)
Soil threat(s):	soil erosion and soil pollution. A general soil degradation process is found due to the increase in machinery (heavy machinery), pesticides, soil compaction, loss of soil structure and reduction in water retention by soils.
Stakeholders:	Workers, farmers, policy makers, inhabitants and governmental agents of villages, scientists, cooperatives' members
Policy Strategy:	Review of the main Policy documents on local, regional and national level (depending on availability) regarding the dominant land use and soils. CAP as implemented by Valencian Government
Representative regions:	irrigated agricultural areas across the Mediterranean such as in Italy, Greece, Slovenia, Cyprus, France, Turkey, Croatia, Malta or Albania

The agricultural land is affected using herbicides and the biological diversity is very low. The introduction of catch crops and cover crops is necessary to increase biodiversity. In general, most of the soils of the study area are bare due to ploughing and herbicide use. Most of the soils at the Canyoles river watershed are managed today with glyphosate, although tillage was the millennia-old management in the study area such as Iberian settlements of 2500 years old shown in the region. In the past, flood irrigation was relevant to achieve proper management of the water. The springs and rivers supplied the water for irrigation, and the fields acted as sinks of sediments and carbon, nutrients, and biota. The water that floods the fields also recharged the aquifer and enriched other springs in the coastal land and lower valleys. The role of terraces in the slopes and the traditional flood irrigation fields contributed to sustainable management that used the sediments coming from the slopes to feed the soils in the alluvial terraces and pediments.

The soils are classified as Calcic cambisols (96 %) and Eutric fluvisols (4 %). The soils in the lower part of the valley are deep and used for agriculture, meanwhile the soils in the mountains are shallow and found in the pockets of the dissolution of the rocks. Figure 9 shows the example of shallow terra rossa soils and the accumulation in the lower part of the valley.

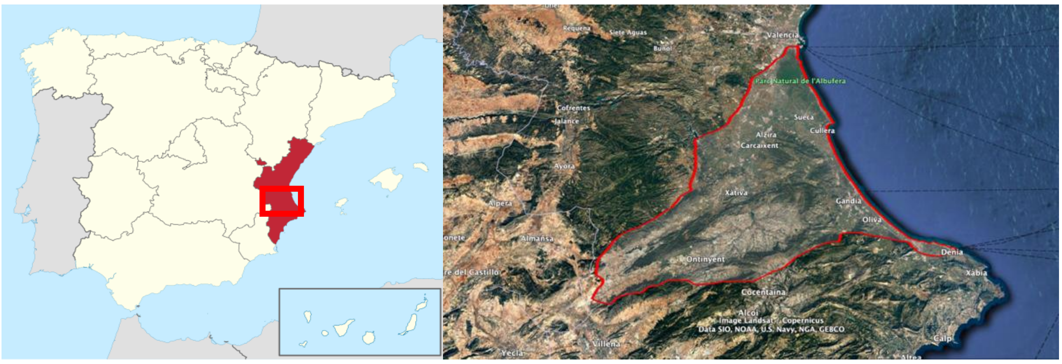


Figure 3-1:Map of the Comunitat Valenciana, Spain

3.2 Stakeholder Interaction

The Figure 3-2shows the different categories of stakeholders interacted during the soil needs assessment workshops and interviews in the Comunitat Valenciana, Spain. A workshop done on the 14th of January 2023 in Xàtiva, Spain. Pre- and post-meeting interviews lasted three months of work to achieve a general view of the stakeholders at the study area.Seventy-nine stakeholders were identified and invited by the research team with previous personal interviews. Attendees: total 39 participants, 8 female, 31 male, 3 from administration, 5 business, 3 education, 1 environmental protection, 2 extension officer for agriculture, 10 farmers, 3 in forestry, 4 landowners, 3 policy makers, 2 researchers, 3 water managers. 10 interviews in March and April 2023 with, an economist from the Valencian Generalitat; three private farmers using agro-chemicals and drip irrigation.

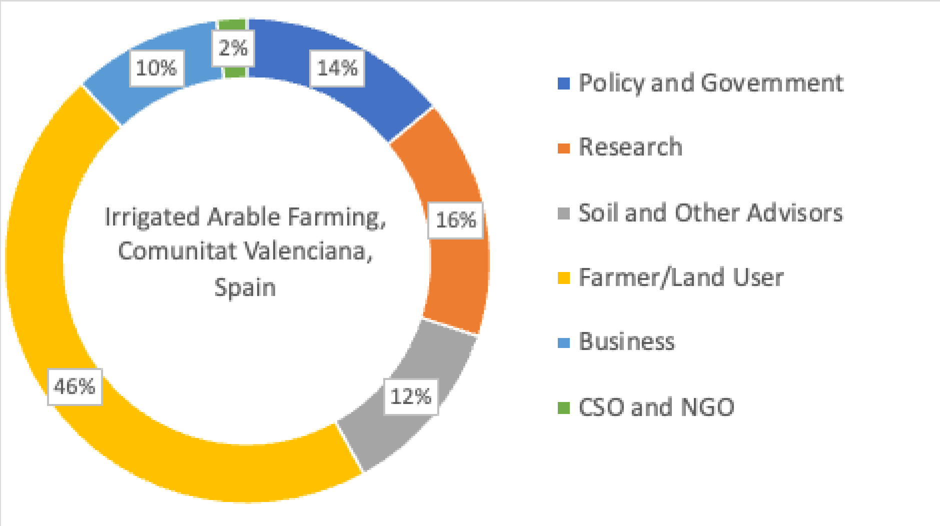


Figure 3-2: Stakeholder interaction in Comunitat Valenciana, Spain

3.3 Soil Needs Assessment

3.3.1 Drivers

Biophysical drivers: Natural drivers and climate change**:** The natural conditions of the Mediterranean climate contribute to accelerate the soil erosion rates due to the concentration of the rainfall in high intense thunderstorms. The low frequency – high magnitude rainfall events favour that soil erosion rates are triggered once the flat flooding fields built on terraces were transformed into sloping fields where soil erosion induced the formation of rills and gullies on bare soils treated with herbicides. Moreover, climate change induces changes in the seasonal distribution of rainfall and the increase in rainfall concentration that enhance soil erosion rates.

Drivers of water-related issues:

1. Climate change-induced droughts and erratic rainfall events with high-intensity rainfall.
2. Land abandonment in former rangelands and steep dryland cropping areas contributes to the restoration of the land but induces the loss of agricultural land for farmers. In many irrigated land, the abandonment is related to the loss of economic income and the pressure of urbanization. Abandonment contributes to the loss of the irrigation system.
3. Technology and economically driven land management change:
    a. Rural areas upstream: traditional flood irrigation in the valleys and dryland on terraced hillslopes to mechanized drip irrigated slopes with land abandonment in the valleys.
    b. Close to Valencia city and close to smaller cities: soil sealing of Huertas by industrial developments and housing. Abandonment of agricultural land

c. Lack of discharge in the Albufera springs due to the depletion of the aquifer as a consequence of the expansion of the drip irrigation systems in the hills?

Socioeconomic drivers: The Valencia PREPSOIL region went through a massive transition regarding irrigation in different parts of the region, from the coastal land to the inland. In the more inland area, the land used changed in 30 years from mostly dryland cropping (olives, apricots, and plums) to now mainly cropping citrus.Since 1986 Spain is a member of the European Union (European Economic Community) and member of the Common Agricultural Policy (CAP). The citrus production was already for more than a century a commercial crop with Europe as the main market, but the EU commercial agreements resulted in a quick expansion of the citrus farms. The expansion of the citrus requested an increase in water use and the aquifers was used to expand the citrus orchards to the slopes. In the 2000s another crop expansion took place (persimmon) based on the drip irrigation, highly technical crops, mechanization, pesticides, and bare-crusted soils due to the abuse of herbicides.

European subsidies to invest in the drip irrigation system were the key to support the shift from a traditional rainfed and irrigation (flooding) agriculture system to a drip-irrigated one. This induced a loss of the traditional heritage in Mediterranean agriculture and the degradation of the soils as a consequence of the bare soils, pesticides, monoculture, and drip irrigation. A human impact of the new agriculture is the loss of the rural population as a consequence of aging and the mechanization of the farms. There is also a loss in the traditional structure of the landowners as new large companies are colonizing the best lands and degrading the cohesion of the farmer communities. This can be seen in the traditional irrigation communities based on flooding, which are not any more communities with a word in the management.

There were several drivers that initiated this change:

- availability of better-paid work at the coast in the tourism sector.
- availability of chemical products for intensive farming.
- availability of subsidies from the European Union for the implementation of drip irrigation.
- the low prices of agricultural products making intensification necessary.

Soil erosion was a consequence of agriculture (traditional rainfed with tillage), overgrazing and fires in the scrublands and forest of the Canyoles river basin. This is not different of the land degradation processes that took place in the Mediterranean for millennia. Land abandonment affected the grazing areas and the rainfed traditional crops such as olive, vineyards, and carobs, and induced the recovery of the rangelands and field with shrublands and Aleppo pines from 1960’s till today in the mountainous terrain. In the lowlands the expansion of the citrus (and persimmon) plantations induced the transformation of traditional agriculture terraces into new plantations and the expansion of the irrigation systems (drip) into sloping terrains. The consequence was a quick degradation of the soils and an increase in soil erosion rates.

The economy of the region is largely based on tourism and services, but also agriculture plays an important economic role. The current agriculture is focused on the growth of commercial crops such as citrus and persimmon. The expansion of citrus and persimmon cultivation over the last 60 years has had a substantial impact on water resources and ecosystem services due to a sharp increase in water demand due to expansion of the irrigation, which has resulted in aquifer depletion, and an increase in soil erosion rates (Cerdà et al., 2018; Keesstra et al., 2019). In addition, industrialization of the towns such as Canals and Vallada in the 1960s and 1980s, respectively, and the development of a society of services transformed the agrarian society.

3.3.2 Pressures

The main soil degradation problems identified in the Canyoles River watershed are soil erosion and soil compaction for stakeholders: technicians, scientists, and policymakers. However, for the farmer different problems were identified: aging, the lack of succession, and low income, although they agreed that soil erosion is damaging their field and production. Soil erosion was a consequence of agriculture (traditional rainfed with tillage), overgrazing and fires in the scrublands and forest of the Canyoles river basin. This is not different of the land degradation processes that took place in the Mediterranean for millennia.

Land abandonment affected the grazing areas and the rainfed traditional crops such as olive, vineyards, and carobs, and induced the recovery of the rangelands and areas with shrublands and Aleppo pines from the 1960's till today in the mountainous terrain. In the lowlands the expansion of the citrus (and persimmon) plantations induced the transformation of traditional agriculture terraces into new plantations and the expansion of the irrigation systems (drip) into sloping terrains. The consequence was a quick degradation of the soils and an increase in soil erosion rates.

Some of the stakeholder's opinions on the pressures are:

Regional government: The expansion of drip irrigation resulted in the depletion of the aquifer. This is local and also regional. After the spread of the new irrigation the disappearance of rivers. This even affects even coastal sediment behavior. We export this water to Europe. The use of herbicides is more general now, which in combination with the drip irrigation allows for agriculture in mountainous terrain which in turn results in high erosion rates and removal or traditional agricultural terraces on the hillslopes and land abandonement in the valley.

Agricultural worker: The arrival of drip irrigation increased the mechanization and the use of chemicals. More pesticides, more herbicides, more chemical fertilizers.

Chemical farmers: Chemicals are necessary, and we need to make the land more productive and the only solution for sustainable agriculture for the farmers; but the problem is that immigrations reduces the salaries.

Organic farmers: there is a loss of biodiversity, loss of fertile soils, loss of cultural heritage such as flood irrigation and agricutlrural terraces. We need to use agriculture to restore the land. No chemicals, no tillage is the only solution to the problems of agriculture and the Planet.

Scientist (economist): big changes at hand due to climate change, but technology can help to improve the production. Environmental change depend on the region.

Landowner: New roads (asfalt) due to new urbanization due to the small houses for drip irrigation. Drip irrigation changed everything. More vehicles. There is more no-tillage. Chipped pruned branches. Drip irrigation allow no tillage. Chemical (herbicides). Tillage.

3.3.3 State

Soils are considered fertile. The millennia-old abuse of tillage and recent herbicides induce the degradation of the soil system and its services. There is a general loss of natural resources such as biodiversity, quality of water, quality of soil, and damage to the traditional landscape. The economy of the Valencia region is largely based on tourism and services, but also agriculture plays an important economic role. The current agriculture is focused on the growth of commercial crops such as citrus and persimmon. The expansion of citrus and persimmon cultivation over the last 60 years has had a substantial impact on water resources and ecosystem services due to a sharp increase in water demand due to expansion of the irrigation, which has resulted in aquifer depletion, and increase in soil erosion rates (Cerdà et al., 2018; Keesstra et al., 2019). In addition, industrialization of the towns such as Canals and Vallada in the 1960s and 1980s, respectively, and the development of a society of services transformed the agrarian society.

State of Soil:

- Severe erosion: erosion due to removal of agriculture terraces and longer steeper slopes and bare surfaces with low roughness and downstream water bodies such as reservoirs and drainage clog up with sediments and soils lost the most fertile upper soil layer due to soil erosion.
- Soil sealing in the peri-urban area reduces infiltration and adds to flood risks.
- Soil compaction due to the abuse of chemicals (herbicides) and heavy machinery. This will increase the runoff discharge

State of Water resources:

- Groundwater level dropping due to pumping of drip irrigation water: as a consequence, springs run dry. The Albufera Lake cannot wash most of the pollutants and resulting in a degraded water body.
- Surface water is polluted with agrochemicals, especially a problem in Albufera and near the coastal land.
- Droughts, soils unable to store water due to poor soil health and the increase in drought periods. Soils are depleted in organic matter due to herbicide use, tillage and the lack of organic fertilization.
- Flood irrigation ditches are removed (no need with drip irrigation) but also drainage network is removed with this: causes flooding during heavy rainfall. With the removal of the irrigation system, we also remove the drainage system.

State of Biodiversity:

- Lack of organic fertilization. Farmers use now more chemicals to fertilize the soil and control the plagues.
- (soil) biodiversity decline due to herbicide and pesticide use
- Increase in plagues, such as mosquito tigers in the wetlands, wild boards or insects.
- Destruction of biodiverse habitats in rainfed and flood irrigation agriculture land

State of Socio-economy:

- Loss of the communal and societal relationship by farmers due to the loss of the common management of resources such as water.
- low soil fertility (inducing higher agro-chemical demands, increasing the costs).

3.3.4 Impacts

Most of the impacts that agriculture and irrigation cause in the study area are known by the farmers but most of those impacts are accepted. Here we review the opinion of the stakeholders.

Water quality and quantity: Pollution by nitrates. Quality of water degraded by chemical agriculture. Water is now available for drinking due to the pollution by nitrates. The new chemical agriculture polluted the aquifer. Some damages are for centuries. There is a shortage in runoff discharge from the springs due to aquifer depletion. This is a high impact on the ecosystems as rivers run dry most of the year (Riu de Sants). Most of the stakeholders accept changes in runoff and quality of water took place, but farmers (chemical farmers) accept this change as payment for more productive agriculture, although all of them would like to recover the environmental health of the past agriculture.

Flooding: More runoff discharge. Also climate change. Fewer sinks and more sources due to changes in agriculture with the new cultivation on a slope. Urbanization in many agricultural lands. In general, most of the stakeholders do not find a relationship between farming and flooding. However, they accept that the new agriculture contributes to more sudden flows from the slopes due to the use of herbicides and the removal of the agriculture terraces.

Droughts: This is not related to agriculture, is more climate changes. The farmers insisted on climate change as a main problem. All the stakeholders accept that climate change is the cause of many problems in agriculture. They see the drought of summer as natural and part of the Mediterranean climate, however, they found that droughts are getting more recurrent and due to the lowering of the groundwater levels the cost of extraction is growing (price of the electricity) and some farms are abandoned due to the high prices of water and the low prices of the agriculture products.

Rural development: Most of the farmers (chemical ones) did not understand the concept of Rural development and we informed them about the main impact of rural development on the future of the region. Furthermore, changes in agriculture (mechanization and Induced abandonment in some places (Font de la Figuera) contributed to an increase in economic activity (Montesa). There is a contrasted response that is mainly related to the changes in irrigation. Irrigation and mechanization are the key factors. Citrus and Persimmons arrived and changed rural development. Wine in Font de la Figuera too. But finally, there is also aging and migration to the cities. There is a loss of population in agricultural land. We need to plan better the changes in agriculture to avoid aging and migration of farmers to other sectors. There is also a need to increase productivity without the loss of environmental values and damage to nature. Organic farming can be the solution (Manuel Asensi, Inma Orozco) but most of the farmers doubt that without chemicals they can survive within competitive agriculture.

The yield of crops: Increased. This is the general opinion of the farmers: more chemical is more production, more yield. Manuel Asensi (organic farmer) point out that at long term the production with be not sustainable due to the cost of degradation of soils and the need of fertilization.

Biodiversity: Decreased. This is a general agreement as the lost of biodiversity is found for flora and fauna. Most of the farmers remembered the life in irrigation ditches in the past and the wildlife in the rivers.

3.3.5 Response

The meeting with the farmers that took place on January 14th,2023, and previous meetings and interviews to prepare this meeting showed that the main soil degradation problems in the Canyoles river watershed that were identified are soil erosion and soil compaction for stakeholder groups technicians, scientists as well as policymakers. However, for the farmers, different problems were identified: aging, the lack of succession, and low income, although they agreed that soil erosion is damaging their fields and production.

In general, soil erosion was seen as the main threat to the agricultural soil in the Canyoles river watershed, as a consequence of the abuse of tillage and herbicides. During our meeting at Casa Cuesa the organizers highlighted the fact that each gram of soil lost is the loss of nutrients, life, and resources. We also informed about the different strategies to control soil erosion and runoff discharge in agricultural land and showed an example with posters of straw mulch, vegetation strips, geotextiles, cover crops, catch crops, and abandonment. Finally, we present the use of chipped pruned branches used as mulch. We did a vote about which they preferred, and this was the result: straw mulch (3), vegetation strips (3), geotextiles (1), cover crops (3), catch crops (8), chipped pruned branches as a mulch (49) and abandonment (1). Twelve participants did not vote.

We requested the participants to find solutions to the soil degradation issue (including land degradation, and social and economic constraints).

The following solutions that address some of the problems above were identified:

- Encourage young people to participate in the new agriculture, healthier agriculture.
- Reduce soil losses with the use of chopped pruned branches and other mulches.
- Reduce the use of pesticides.
- Increase prices of agricultural products.
- Recover the use of manure, and for this, we need organic farms.

Farmers in general are claiming for a chemical agriculture and fair prices and salaries

- there is a large diversity of farmers and stakeholders involved, from organic farming to conventional farmers, with contrasted views on the future of agriculture.
- the economic challenge (viability) is the unique common agreement. Farms need to be economically viable to be successful. How to achieve sustainability is a matter of discussion between farmers.
- loss of income, low prices, more economic constraints day after day due to the low prices and increase in the cost of production.
- Ageing and lack of replacement is the main general problem.
- Contrasted views between the organic-chemical farmers, between large and small, professional and partial-time farmers… The diversity is huge.
- Farmers agree that the damage in nature is high, but no way to find solutions. Organic farmers suggest moving to organic farming but 95 % of the agriculture in the region is conventional and difficult to change the management.
- There are some managements that contribute to restoring the soil health and are more and more welcome by the farmers (chipped pruned branches) but others are rejected by the farmers (remove the use of herbicides, catch crops, or avoid the use of pesticides).

Specific comments of our interviewees:

A**gricultural worker:** would like to see the that the society will be aware of the cost of production and the live of the farmers in the fields (workers).

Chemical farmers: would like to see strong agribusiness, good income and good salaries. He claims for fair prices and more subsidies. He does not trust in politicians as farmers are being seeing as second-class citizens. **And more** and stronger pesticides and herbicides are needed. We need to change governments and built our own political party, remove politicians and more farmers, with good salaries and fair prices, and he thinks that today problems is more due to politicians

Organic farmers claims for better prices and focuses on traditional agriculture, using nature based solutions that give solutions for free. Just we need wisdom and good governance. Organic farming is the future. Aging is a big problem to change the landscape. We need policies to bring new farmers. The need of more conexion within the farmers.To make the agriculture more viable from an economical point of view. The economy is definitive.

Regional government: ones state that forty years ago, with rivers, and irrigation ditche the landscape was a paradise. River and orchards and gardens in fair production. He would like to restore this land and maintain this as sustainable. But it is almost impossible. But there is a need to change governance with a longer view thank only 4 years until the next election. We need to restore many things (water, irrigation system, cultivars, farmers, knowledge, etc). also citizens need to be aware of the value of their own land, now there is a big distance between most citizens and the landscape. there is no need for more production (we produce a lot in Valencia), but reducing production is very difficult. Most of the policies are in the direction of land degradation. More irrigation, more cultivation on the slopes, new cultivars more productive but less resilient. And nobody acknowledges the importance of the cultural landscape of Mediterranean agriculture. So we need education to control and reduce the urban expansion and preserve soils, recover the traditional agriculture from the mountainous terrain (inland), preserve the gardens, coastal land and biodiversity to achieve a harmonious relationship between nature and humans. We must protect the land and the people from the market.

Scientist: Health, education, pensions, housing, food are the five pillars of a society. As good as this five pillars you are better your society are better. We need this for the young people. I dream for my children this. Better ideas, better policies, and work for the people rights. Laws is not enough. Police is not enough. The water and carbon print is the key issue. If we do not improve this we are dead. We need to be proud to be sustainable. To be environmental friendly.

3.4 Conclusions

In the Valencia region, the traditional flood irrigation was fed with natural karstic springs, as in many regions around the Mediterranean) where limestones are rocks widely distributed. In the La Ribera district, the river Xúquer allowed a large flood irrigation system that is millennia old. This sustainable system is being changed into drip irrigated areas recently. Drip irrigation brings a large industrialization of agriculture with it and promotes the use of chemical fertilizers, and herbicides. The agriculture terraces are destroyed to facilitate the use of tractors and mechanize the labour. To avoid weeds, large amounts of herbicides are applied. Other agrochemicals are used to control the pests. This system is very productive in terms of the amount of citrus that can be produced but has several negative impacts, such as the loss of biodiversity, which affect the soil biota and larger fauna such as rodents and birds as well as above-ground insects. The downstream waterbodies are also affected. Secondly, the social structure of the community is lost. Thirdly, the removed irrigation channels cannot provide their drainage function in the case of large amounts of precipitation. Lastly, the landscape in terms of cultural heritage and attractiveness for agri-tourism deteriorates.

The situation in the region was assessed by a literature review, a workshop done on the 14th of January 2023 in Xàtiva, Spain with 38 participants and an additional 10 in-depth interviews.

The agricultural land is affected by the use of herbicides and the biological diversity is very low. The introduction of catch crops and cover crops is necessary to increase biodiversity. In general, most of the soils of the study area are bare due to ploughing and herbicide use. Most of the soils at the Canyoles river watershed are managed today with glyphosate, although tillage was the millennia-old management in the study area such as Iberian settlements of 2500 years old shown in the region. In the past, flood irrigation was relevant to achieve proper management of the water. The springs and rivers supplied the water for irrigation, and the fields acted as sinks of sediments and carbon, nutrients, and biota. The water that floods the fields also recharged the aquifer and enriched other springs in the coastal land and lower valleys. The role of terraces in the slopes and the traditional flood irrigation fields contributed to sustainable management that used the sediments coming from the slopes to feed the soils in the alluvial terraces and pediments.

The soils are classified as Calcic cambisols (96 %) and Eutric fluvisols (4 %). The soils in the lower part of the valley are deep and used for agriculture, meanwhile the soils in the mountains are shallow and found in the pockets of the dissolution of the rocks.

The following solutions that address some of the problems above were identified:

- Encourage young people to participate in the new agriculture, healthier agriculture.
- Reduce soil losses with the use of chopped pruned branches and other mulches.

- Reduce the use of pesticides.
- Increase prices of agricultural products.
- Recover the use of manure, and for this, we need organic farms.

However, farmers in general are claiming for a chemical agriculture and fair prices and salaries.

3.5 References

Cerdà, A., Daliakopoulos, I. N., Terol, E., Novara, A., Fatahi, Y., Moradi, E., ... & Pulido, M. 2021. Long-term monitoring of soil bulk density and erosion rates in two Prunus Persica (L) plantations under flood irrigation and glyphosate herbicide treatment in La Ribera district, Spain. Journal of Environmental Management, 282, 111965.

Cerdà, A., Novara, A., & Moradi, E. 2021. Long-term non-sustainable soil erosion rates and soil compaction in drip-irrigated citrus plantation in Eastern Iberian Peninsula. Science of The Total Environment, 787, 147549.

Cerdà, A., Terol, E., & Daliakopoulos, I. N. 2021. Weed cover controls soil and water losses in rainfed olive groves in Sierra de Enguera, eastern Iberian Peninsula. Journal of Environmental Management, 290, 112516.

Cerdà, A., Rodrigo-Comino, J., Yakupoğlu, T., Dindaroğlu, T., Terol, E., Mora-Navarro, G., & Vaverková, M. D. 2020. Tillage Versus No-Tillage. Soil Properties and Hydrology in an Organic Persimmon Farm in Eastern Iberian Peninsula. Water, 12(6), 1539.

Cerdà, A., & Rodrigo-Comino, J. 2020. Is the hillslope position relevant for runoff and soil loss activation under high rainfall conditions in vineyards?. Ecohydrology & Hydrobiology, 20(1), 59-72.

Keesstra, S. D., Rodrigo-Comino, J., Novara, A., Giménez-Morera, A., Pulido, M., Di Prima, S., & Cerdà, A. 2019. Straw mulch as a sustainable solution to decrease runoff and erosion in glyphosate-treated clementine plantations in Eastern Spain. An assessment using rainfall simulation experiments. Catena, 174, 95-103.

Cerdà, A., Rodrigo-Comino, J., Giménez-Morera, A., Novara, A., Pulido, M., Kapović-Solomun, M., & Keesstra, S. D. 2018. Policies can help to apply successful strategies to control soil and water losses. The case of chipped pruned branches (CPB) in Mediterranean citrus plantations. Land Use Policy, 75, 734-745.

Cerdà, A., Rodrigo-Comino, J., Giménez-Morera, A., & Keesstra, S. D. 2018. Hydrological and erosional impact and farmer’s perception on catch crops and weeds in citrus organic farming in Canyoles river watershed, Eastern Spain. Agriculture, Ecosystems & Environment, 258, 49-58.

Cerda, A., Rodrigo-Comino, J., Novara, A., Brevik, E. C., Vaezi, A. R., Pulido, M., ... & Keesstra, S. D. 2018. Long-term impact of rainfed agricultural land abandonment on soil erosion in the Western Mediterranean basin. Progress in Physical Geography: Earth and Environment, 42(2), 202-219.

Cerdà, A., Rodrigo-Comino, J., Giménez-Morera, A., & Keesstra, S. D. 2017. An economic, perception and biophysical approach to the use of oat straw as mulch in Mediterranean rainfed agriculture land. Ecological Engineering, 108, 162-171.

Cerdà, A., Keesstra, S. D., Rodrigo-Comino, J., Novara, A., Pereira, P., Brevik, E., & Jordán, A. 2017. Runoff initiation, soil detachment and connectivity are enhanced as a consequence of vineyards plantations. Journal of Environmental Management, 202, 268-275.

Cerdà, A., González-Pelayo, Ó., Giménez-Morera, A., Jordán, A., Pereira, P., Novara, A., & Orenes, F. G. 2016. Use of barley straw residues to avoid high erosion and runoff rates on persimmon plantations in Eastern Spain under low frequency–high magnitude simulated rainfall events. Soil Research, 54(2), 154-165.

Vera-Herrera, L., Romo, S., & Soria, J. (2022). How agriculture, connectivity and water management can affect water quality of a Mediterranean coastal wetland. *Agronomy*, *12*(2), 486.

4 Olive Tree Cultivation: Andalucia, Spain

Iván Sánchez-Castro (EEZ-CSIC; ivan.sanchez@eez.csic.es), Ana Segura (EEZ-CSIC; ana.segura@eez.csic.es)

4.1 Regional Information

More than 10 million ha worldwide are used for olive tree (*Olea europaea* L.) cultivation. At the European level, the surface dedicated for this purpose is approximately 4,6 million ha, most of it (95%) in the Mediterranean basin, where winters are cold and wet and summers are hot and dry. The NUTS3-region coded as ES616 (Jaén, Spain;Figure 4-1 and Table 4-1) was selected as a representative area where olive tree crops dominate, forming Mediterranean socio-ecological landscapes.

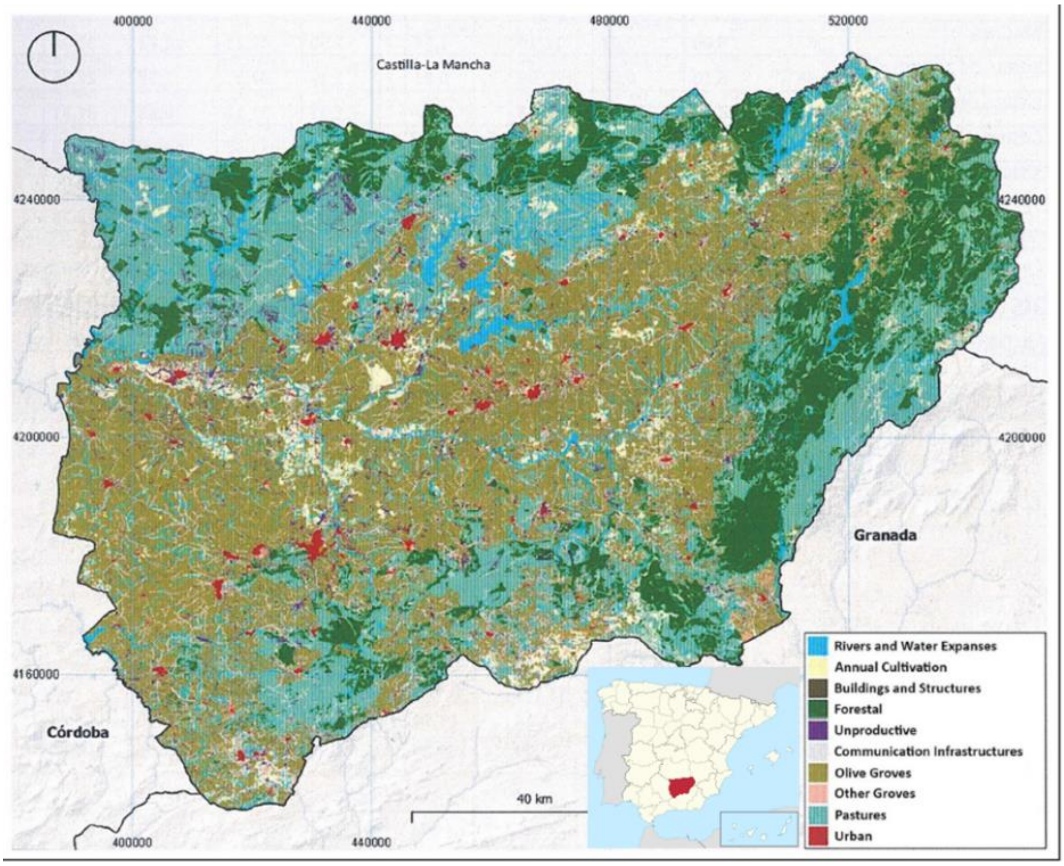


Figure 4-1: Map of the primary soil usages in the province of Jaén, Spain in 2020

Source:Koch 2023

Cultivation of olive trees mainly occurs in two major and distinct ways: (i) traditional, extensive, widely spaced, rain-fed orchards; and (ii) modern, high-density, intensive/super-intensive, irrigated orchards. Although in the recent past most of the world's olive orchards belonged to the first type, the trend in the last few decades has been a shift to the second type, leading to an increase in oil production. However, these intensive cultivation practices, as well as the combination of frequent cultivating steep slopes with low density of trees (in traditional cultivation systems), together with climate change consequences (e.g., intense rainstorms), are leading to a decrease in soil health (Gomez 2009), mainly by:

- the depletion of soil organic matter
- reduction of biodiversity
- eventual off site contamination
- massive soil erosion
- desertification
- degradation of soil and water resources by overexploitation

The adoption of management models promoting olive grove resilience in face of these determining factors seems essential to ensure their socio-ecological sustainability.

Table 4-1:Regional information of olive-tree cultivation region in Jaén, Spain

Dominant land use:	Agriculture (predominantly, traditional olive trees rain-fed cultivation). 78% of the agricultural surface in this region (ES616) is dedicated to olive groves.
Secondary land use:	Natural/forestry, urban (rural).
Climatic Zone:	Mediterranean: mean annual temperature ranging from 7-18 °C and a mean annual precipitation of 400–570 mm (xeric soil moisture regimen). Occasional summer droughts.
Soil WRB classification:	Mainly cambisol and regosol.
Soil type:	Carbonated materials (marls, limestones and dolostones). High calcium carbonate content and high pH (6-8). Low nutrients content.
Dominant topsoil texture:	Mainly coarse texture and high stone content. Loam to clay in some areas.
Soil threat(s):	Erosion (water), desertification, salinization, pollution, compaction.
Representative for regions:	ES61 (Andalusia), ES42 (Castilla la Mancha), ES43 (Extremadura) / EL65 (Peloponnese), EL43 (Crete), EL62 (Ionian Islands) / ITF4 (Apulia), ITF6 (Calabria), ITF2 (Molise) / CY (Cyprus). Other olive-

	growing Mediterranean regions (Italy, Greece, Cyprus, Croatia, etc.).

4.2 Stakeholders Interaction

The Figure 4-2 shows the different categories of stakeholders interacted during the soil needs assessment workshops and interviews in the Andalucia region. On 17 March 2023, at the Institute of Research in Olive Groves and Olive Oil (INUO) located in Jaén (Spain), a dedicated workshop was celebrated about the soil health needs in olive groves. This workshop congregated different olive trees cultivation stakeholders (politicians, agricultural organizations, researchers and others) that discussed about the health of soils in olive tree plantations.

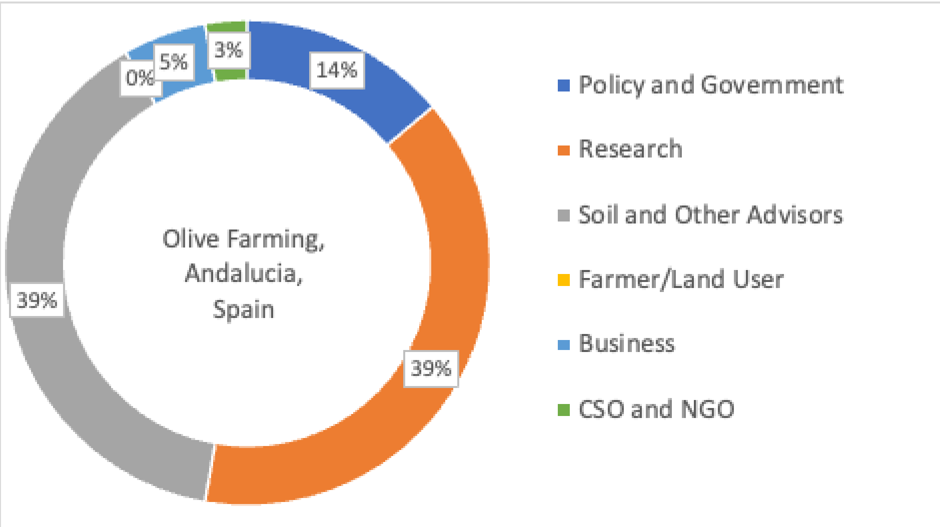


Figure 4-2: Stakeholder interaction in Andalucia, Spain

4.3 Soil Needs Assessment

4.3.1 Drivers

Biophysical drivers: The main biophysical driver threatening the soil health in olive orchards and then olive production sustainability is climate change, which has several consequences directly affecting soil health parameters (Michalopoulos et al. 2020):

- Increase *of temperatures*: human-induced global warming is presently increasing at a rate of 0.2°C per decade. These warmer temperatures over time are changing weather patterns and disrupting the usual balance of nature. In the Mediterranean region, certain scientific models predict a significant increase in air temperatures higher than 6 °C in summer on the Iberian Peninsula (Viceto et al. 2019).

- Decrease *in rainfall*: a decrease in total rainfall rates was also predicted (Gibelin and Déqué 2003), and Mediterranean regions currently suffer from it, inducing droughts in some cases. Moreover, the occurrence of intense rainstorms is more frequent, contributing to the acceleration of soil erosion rates.

The alterations in rainfall regime and water levels, as well as extreme fluctuations in temperature, make the soil more vulnerable to degradation processes such as erosion. In addition, prolonged droughts can prevent plants from growing, leaving soil further exposed. The effects of climate change in Mediterranean regions (where most olive orchards are located) are becoming more pronounced.

Climate change is hardly reversible, and it is expected to be active, to a greater or lesser extent, in the long term. Current **predictions of climate conditions** for the next decades in the olive-growing areas of Andalusia confirm the prediction of a significant decrease in annual rainfall as well as an increase in temperature and evapotranspiration.

Socioeconomic drivers: Several socioeconomic drivers at different levels, posing an increase in the pressure that soils in olive groves may experience, have been identified throughout this study and are listed below:

- Economic: Factors such as the decrease in olive grove productivity because of certain biophysical drivers or fluctuations in market prices for olive tree-derived products are known to compromise the economic viability of olive groves, leading to either **land abandonment** or **crop intensification**. While land abandonment may contribute to natural restoration, the farming intensification needed to **maintain crop yields significantly** increases the pressure on the soil.
- Application *of traditional practices*: historically, the agricultural sector tends to be very **conservative,** likely caused by the **high average age** and **low education level** of some farmers and the **complicated access to certain sources of knowledge**. Certain practices (over-tillage, bare soil keeping, etc.) used for a long time are difficult to eradicate and are applied by default, even if they are known to provide more disadvantages than advantages.
- Land *tenure/management situation:* the **high number of small farmers** in the province of Jaén (Parras Rosa et al. 2020) may hinder easy coordination and communication among them, resulting in suboptimal soil management practices. On the other hand, huge extensions are being accumulated by **single landowners or investment funds,** which may

also have negative implications for soil sustainability management due to a lack of interest in maintaining the health of the land they are cultivating in the long term.

- Political *and legal changes:* olive tree cultivation is subjected to **European, national, and regional legislation** on environmental, climate, and agricultural topics. **Subsidies from the CAP**, financed by European authorities, and others financed by local and regional authorities are also conceived to incentivize soil-friendly practices, which can have a positive impact on soil health in the medium and long term.
- Technological *innovations:* this technological driver may have a negative effect on the environment, and specifically on soil. However, nowadays, this situation is changing, and numerous efforts are being made to investigate environmentally friendly **technologies** that may collaborate decisively on implementing long-term sustainable agricultural strategies.

4.3.2 Pressures

The olive-oil sector is transitioning from **traditional** models to **intensive** and **super-intensive** models to compensate for the negative effects caused by the *drivers* described above. In this way, the productivity of olive groves per hectare is not affected negatively and, in most cases, is even higher compared to traditional models. The main differences between traditional, intensive, and super-intensive olive groves are related to **plant density** (higher-intensive or super-intensive groves), **mechanization degree** (higher-intensive/super-intensive groves), **irrigation regime** (higher use of water and complex irrigation systems in intensive/super-intensive groves), and **application of fertilizers and pesticides or other agronomic operations as tillage** (higher in intensive/super-intensive groves). This intensification process in the cultivation practices, together with "unmanageable" climate change effects (e.g., intense Mediterranean rainstorms), is known to affect especially the soil health in traditional olive tree crops where **slopes are steep** and the density of trees is low. In this sense, the steeper the orchard, the higher the risk of erosion. Additionally, **agriculture terraces** are being removed to mechanize the new crops, which increases soil erosion.

Although the quality of the final product seems not to be compromised by using these intensive and super-intensive models, these intensification practices are closely tied to the acceleration of soil erosive episodes and other degradative processes, posing additional pressure on soil health mainly due to:

- Use of heavy machinery: compaction/degradation of soil structure
- Increase in the use of fertilizers: possible contamination of natural resources (e.g., soil, water)

- Use of pesticides (e.g., herbicides): decrease in the diversity of flora, fauna, and soil microbial communities
- Recurrent tillage: negatively affects the soil's physical and biological properties.

From a **socio-political perspective**, the current **CAP-subsidies system** clearly creates pressures on soil health for olive farmers in both negative and positive ways. Compensation for banned practices by intensifying some others allowed by CAP with the purpose of receiving CAP subsidies without reducing economic benefits may clearly exacerbate soil health degradation. In view of this situation, the latest CAP reforms have focused on promoting sustainable soil management. Nevertheless, there is still a high proportion of farmers removing plant cover by tillage, herbicides, or both (MAGRAMA 2015).

4.3.3 State

Pressures described in the previous section lead to soil deterioration at different levels (e.g., depletion of soil organic matter, erosion, desertification, or degradation of water resources). While some parameters have been widely studied and consistently used as **soil health indicators** (e.g., pH, SOC, or porosity), others have still remained poorly investigated in this region, with limited and sparse data availability (e.g., loss of biodiversity). Refer Figure 4-3 for additional information of the stakeholder perceptions o nthe status of soil health. In this sense, a new attempt to establish a universal complex indicator enabling little-used qualitative morpho-pedological data to be managed and integrated into a single **Field Soil Quality Index** (FSQI) was proposed and tested in the soil of olive-growing areas such as the province of Jaen (Calero et al. 2018).

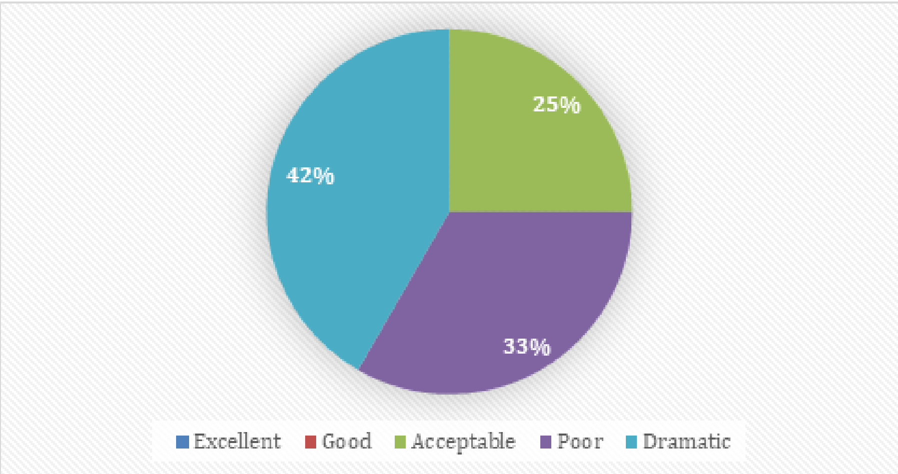


Figure 4-3: Stakeholder perception on the state of the soil in olive groves (n=11)

The main **soil health indicators** used to describe the current **state** of soils in olive groves are:

Erosion: this is considered the **major threat to the sustainability** of this crop (Gomez 2009; Gómez et al. 2009a) as a consequence of multiple factors such as the **Mediterranean climate** (frequent intense rainfalls), **cultivation in sloping areas,** and/or **inappropriate soil management practices** that do not favor the establishment of ground covers**.** Although soil erosion rates accelerated with the mechanization of olive cultivation in the early 1960s, it is suggested in the literature (Gomez 2009) that these effects were previously detected with the intensification of olive cultivation in the region (19th century), becoming more pronounced in the last decades of the 20th century due to changes in soil management practices and technological olive farming intensification (Vanwalleghem et al. 2011).

- Compaction: the use of **heavy machinery**, more common in the case of intensive and super-intensive farming, may lead to **soil structure degradation by compaction** (González-Rosado et al., 2021), especially if soils are clayey. As a direct consequence of this compaction process, the water storage capacity of the soil is significantly reduced while the runoff discharge has increased.
- Soil organic matter (SOC) content: certain management practices in olive groves (e.g., the establishment of ground covers) may induce the **sequestration of atmospheric C in soils**. However, when SOC depletion occurs, crop productivity is negatively affected. These effects in olive groves have been investigated at both the plot scale (Paustian et al., 1996; Lugato and Berti, 2008; Álvaro-Fuentes and Paustian, 2011) and the regional/national scale (Smith et al., 2005). Perspectives are not optimistic in this sense, since soil in olive groves is projected to experience an overall decline in SOC in both the near (2030) and far (2070) futures (Smith et al. 2005).
- Soil nutrient retention: with rising soil temperatures, soil nutrients normally increase in upper soil layers since decomposition rates are boosted (Kirschbaum 1995). For this reason, olive crops are experiencing an overall **increase in soil macronutrients**, including Ca, Mg, K, and Na, in these upper layers. Although this factor could generally benefit production yield, nutrient levels may be imbalanced due to intensive farming practices and erosion.
- Soil contamination: although this is not considered a major issue for this land use, the **accumulation of heavy metals or other organic toxic compounds**, mainly through the use of agrochemicals or wastewater irrigation, may affect the soil health in certain olive orchards (e.g., Mahmoud et al. 2010).

- Soil biodiversity: this parameter may indicate a decline in olive orchard soil health when the use of pesticides and/or over-tillage of soil top layers causes a decrease in soil biodiversity (Moreno et al. 2009).

In brief, the current **biophysical health state of the soil** in olive tree crops was mainly defined as **dramatic** (42% of interacted stakeholders), poor (33%) and acceptable (25%) by stakeholders interacted.

Socioeconomic situation: No specific data have been found in the socioeconomic situation of olive farmers in the target region. A way to approach this reality is through the number of CAP-subsidies applications. It is estimated an average size of 1.24 ha per olive trees plot (total 440,000 plots) with more than 70% of farmers owning less than 5 ha. Since it is estimated that it needs a minimum surface of 10 ha to be able to live exclusively on olive tree cultivation (Parras-Rosa et al. 2020), we can conclude that currently a high number of farmers cannot live off olive farming as their sole economic activity. For this reason, most producers in Jaén owning small cultivation areas are mostly dependent on subsidies. In 2019, more than 80,000 olive farmers applied for CAP subsidies (Parras-Rosa et al. 2020). This high dependence on EU subsidies and the serious aging of the sector support the necessity of a "renewal" in the olive sector in the context of an emerging growth-oriented bioeconomy.

4.3.4 Impacts

The capacity of soils linked to olive tree cultivation to **support ecosystems services** is being reduced in the last decades, affecting certain **soil functions**, as summarized next:

- Crop productivity: the soil degradation attributed to different factors (e.g. water erosion) in olive orchards in Mediterranean regions entail a decrease in productivity in olive yield.
- Water regulation: the role of the soil in olive tree crops (mostly rainfed) as a water reservoir during the dry season is critical to maximize their productivity. Climate change´s consequences accelerate the depletion of aquifers and other soil-decisive parameters like infiltration and water-holding capacities.
- Carbon sequestration and climate change mitigation: certain agricultural practices are known to help mitigate climate change by reducing emissions from agriculture and by storing carbon in plant biomass and soils. Degraded and bare soils in olive groves do not provide this ecosystem service optimally.
- Regulation of drought, flood and fire risks: soil degradation in olive groves (mainly by the use of herbicides and the removal of the agriculture terraces) may increase the frequency and damages caused by these events.
- Degradation/contamination of soil and water resources: runoff of agrochemicals-contaminated water may produce off-site negative effects on soil and water resources (rivers, lakes, arable land, etc.) potentially useful for human leisure/economic utilization.
- Soil biodiversity resources: the loss of soil biodiversity above, within, and below the topsoil is known to negatively affect the resistance and resilience against disturbance and

stress as well as the promotion of soil fertility by some organisms decomposing plant organic matter and enhancing soil structure.

4.3.5 Response

Considering these drivers and pressures and their potential impacts, it is imperative to adopt **adequate adaptation and mitigation strategies,** including regenerative climate-smart measures, with the purpose of regenerating and conserving the soil of olive groves in the long term. Further, the general lack of awareness and knowledge about the benefits that soil and land can deliver and the impacts and costs of unsustainable management should be considered.

Although no standard recipes exist for good soil management in olive-growing areas worldwide, since optimal management depends on local environmental and societal characteristics, the main current responses and strategies to reverse negative impacts on these soils are summarized below:

- Societal-political measures: **policy reforms** play probably one of the most crucial roles in driving changes towards sustainable soil management. To adapt **soil governance** to current challenges and to **involve different stakeholders** should be some of the goals in order to ensure an agile and effective soil use regulation. The right establishment of a **subsidy program** (e.g., CAP) and other measures such as **taxes** and/or **fee** establishment may have a positive impact on the correct choice made by farmers. **Certification or recognition** of environmentally friendly farms would promote these beneficial practices by adding value to their products.
- Soil literacy and stakeholder awareness: capacity-building and education **initiatives** should cover all soil-related stakeholders, including all levels of society, such as schoolchildren, making local people feel engaged in the implementation of diverse activities towards healthier soils. It is at this point where **living labs** make sense for connecting stakeholders through initiatives and activities (consultation processes, workshops, etc.) to facilitate knowledge exchange and fluent communication between all these different stakeholders. **Research institutions** must be a central actor in this regard to provide innovative, sustainable alternatives to local challenges in the olive industry. The availability of **specialized technical staff** to assist soil managers, as well as the creation and easy accessibility of appropriate **communication channels and knowledge repositories** in the local language, are seen as essential actions to banish negative inherited management practices.
- Adoption of sustainable/regenerative soil management practices: main practical measures, highly cited in literature and supported by stakeholders interacted in the

present study, are: i) **use of vegetable ground covers** (Gómez et al. 2009b; Fleskens 2007; Kairis et al. 2013; Palese et al. 2014); ii) **soil amendment application** (Bombino et al. 2021; Calatrava et al. 2007); iii) **no-tillage** (Gómez 2017; Turrini et al. 2017); iv) **controlling pests and managing water and nutrients efficiently** (Bar-Yosef 1999; Neilsen et al. 1999); v) **olive-tree variety optimal selection**

4.4 Conclusions

Olive tree groves occupy a significant area within the Mediterranean region, characterized by cold, wet winters and hot, dry summers. There are two major management strategies: traditional-extensive rain-fed orchards and intensive/super-intensive irrigated orchards. The recent trend to convert traditional orchards into intensive or super-intensive ones is mainly caused by the reduction of productivity related to several drivers, such as climate change and the ambition of large corporations to maximize benefits in the short term. This intensification in the cultivation methods is clearly creating some pressure in ecosystems with special detrimental effects on the soil. As a consequence of these pressures, soil health is decreasing, and the current state of the soil in olive groves is considered dramatic based on several health indicators, such as the depletion of organic matter in the soil or massive soil erosion. The general degraded state of the soil health in olive tree crops produces a negative qualitative and quantitative impact on the ecosystem services offered by olive tree-related soil. Considering that this intensification process seems unstoppable, the desired situation in the future is the adaptation of the new cultivation strategies to the worldwide environmental reality, since prolonged pressures may cause irreversible effects in the soil, which can reduce soil fertility to levels that make them useless for agriculture in a short period of time. Soil managers may be able to reverse this situation through the adoption of sustainable soil management responses.

In summary, the massive soil erosion and the lack of water caused by climate change seem to be the main threats to the medium- and long-term sustainability of this important economic sector. The adoption of management models promoting olive grove resilience in the face of these determining factors seems essential to ensuring their socio-economic viability and environmental sustainability. And for this purpose, targeted research and innovation activities (e.g., selection of resilient olive-tree varieties, design of tailored cover crops, or definition of consistent soil health indicators) are crucial. In this sense, the establishment of living labs focused on this land use seems to accelerate the implementation of soil-friendly agricultural strategies.

4.5 References

Álvaro-Fuentes, J., Paustian, K. 2011. Potential soil carbon sequestration in a semiarid Mediterranean agroecosystem under climate change: quantifying management and climate effects. Plant Soil, 338, pp. 261-272.

Bar-Yosef, B. 1999. Advances in fertigation. In Advances in Agronomy; Academic Press: New York, NY, USA; Volume 65, pp. 1–77.

Bombino, G., Denisi, P., Gómez, J.A., Zema, D.A. 2021. Mulching as best management practice to reduce surface runoff and erosion in steep clayey olive groves. International Soil and Water Conservation Research, 9 (1), 26-36. https://doi.org/10.1016/j.iswcr.2020.10.002.

Calatrava, J., Franco, J.A., González, M.C. 2007. Analysis of the adoption of soil conservation practices in olive groves: The case of mountainous areas in southern Spain. Spanish Journal of Agricultural Research, 5, pp. 249-258.

Calero, J., Aranda, V., Montejo-Ráez, A., Martín-García, J.M. 2018. A new soil quality index based on morpho-pedological indicators as a site-specific web service applied to olive groves in the Province of Jaen (South Spain), Computers and Electronics in Agriculture, 146, 66-76. https://doi.org/10.1016/j.compag.2018.01.016.

Fleskens, L. 2007. Conservation Scenarios for Olive Farming on Sloping Land in the Mediterranean. Wageningen Universiteit, Wageningen, The Netherlands.

Gibelin AL, Déqué M. 2003. Anthropogenic climate change over the Mediterranean region simulated by a global variable resolution model. Clim Dyn., 20:327–339.

Gómez, J. A. (Ed.). 2009. Sostenibilidad de la produccion de olivar en Andalucía. Sevilla: Junta de Andalucía.

Gómez, J. A., Sobrinho, T. A., Giráldez J.V., Fereres, E. 2009a. Soil management effects on runoff, erosion and soil properties in an olive grove of Southern Spain. Soil and Tillage Research, 102 (1), 5-13. https://doi.org/10.1016/j.still.2008.05.005.

Gómez, J. A., Guzmán, M.G., Giráldez, J.V., Fereres, E. 2009b. The influence of cover crops and tillage on water and sediment yield, and on nutrient, and organic matter losses in an olive orchard on a sandy loam soil. Soil and Tillage Research, 106 (1), pp. 137–144, 2009.

Gómez, J.A. 2017. Sustainability using cover crops in Mediterranean tree crops, olives and vines—Challenges and current knowledge. Hung. Geogr. Bull., 66, 13–28.

González-Rosado, M., Parras-Alcántara, L., Aguilera-Huertas, J., Lozano-García, B. 2021. Soil Productivity Degradation in a Long-Term Eroded Olive Orchard under Semiarid Mediterranean Conditions. Agronomy 11, 812. https://doi.org/10.3390/agronomy11040812

Kairis, O., Karavitis, C., Kounalaki, A., Salvati, L., Kosmas, C. 2013. The effect of land management practices on soil erosion and land desertification in an olive grove. Soil Use and Management 29 (4), pp. 597–606.

Kirschbaum, M.U.F. 1995. The temperature dependence of soil organic matter decomposition and the effect of global warming on soil organic carbon storage. Soil Biol. Biochem., 27, pp. 753-760.

Koch, P. 2023. Where limits to growth are tangible: the olive sector in Jaén and its bioeconomic future. Sustain Sci 18, 661–674. https://doi.org/10.1007/s11625-022-01236-6

Lugato, E., Berti, A. 2008. Potential C sequestration in a cultivated soil under different climate change scenarios: a modelling approach for evaluating promising management practices in north-east Italy. Agric. Ecosyst. Environ., 128, pp. 97-103.

MAGRAMA. 2015. Encuesta sobre superficies y rendimientos de cultivos. Ministerio de Agricultura, Alimentación y Medio Ambiente, Madrid

Mahmoud, M., Janssen, M., Haboub, N., Nassour, A., Lennartz, B. 2010. The impact of olive mill wastewater application on flow and transport properties in soils. Soil and Tillage Research, 107 (1), 36-41. https://doi.org/10.1016/j.still.2010.01.002.

Michalopoulos, G., Kasapi, K.A., Koubouris, G., Psarras, G., Arampatzis, G., Hatzigiannakis, E., Kavvadias, V., Xiloyannis, C., Montanaro, G., Malliaraki, S., Angelaki, A., Manolaraki, C., Giakoumaki, G., Reppas, S., Kourgialas, N., Kokkinos, G. 2020. Adaptation of Mediterranean Olive Groves to Climate Change through Sustainable Cultivation Practices. Climate, 8, 54. https://doi.org/10.3390/cli8040054

Moreno, B., Garcia-Rodriguez, S., Cañizares, R., Castro, J., Benítez, E. 2009. Rainfed olive farming in south-eastern Spain: Long-term effect of soil management on biological indicators of soil quality. Agriculture, Ecosystems & Environment, 131 (3–4), 333-339. https://doi.org/10.1016/j.agee.2009.02.011.

Neilsen, G.H., Neilsen, D., Peryea, F. 1999. Response of soil and irrigated fruit trees to fertigation or broadcast application of nitrogen, phosphorus, and potassium. Hort Technology 9, 393–401.

Palese, A.M., Vignozzi, N., Celano, G., Agnelli, A.E., Pagliai, M., Xiloyannis C. 2014. Influence of soil management on soil physical characteristics and water storage in a mature rainfed olive orchard. Soil and Tillage Research, 144, pp. 96–109.

Parras Rosa, M., Ruz Carmona, A., Torres Ruiz, F.J., Colombo, S. 2020. Los costes del olivar en la Provincia de Jaén: tipología de olivareros y aproximación a los costes de los municipios de la Provincia de Jaén. Edita: DIPUTACIÓN PROVINCIAL DE JAÉN, Instituto de Estudios Giennenses. En colaboración con el área de Agricultura, Ganadería, Medio Ambiente y Cambio Climático.

Paustian, K., Elliott, E.T., Peterson, G.A., Killian, K. 1996. Modelling climate, CO2 and management impacts on soil carbon in semi-arid agroecosystems. Plant Soil, 187, pp. 351-365

Smith, J., Smith, P., Wattenbach, M., Zaehle, S., Hiederer, R., Jones, R.J.A., Montanarella, L., Rounsevell, M.D.A., Reginster, I., Ewert, F. 2005. Projected changes in mineral soil carbon of European croplands and grasslands, 1990–2080. Global Change Biol., 11, pp. 2141-2152.

Turrini, A., Caruso, G., Avio, L., Gennai, C., Palla, M., Agnolucci, M., Tomei, P.E., Giovannetti, M., Gucci, R. 2017. Protective green cover enhances soil respiration and native mycorrhizal potential compared with soil tillage in a high-density olive orchard in a long term study. Appl. Soil Ecol. 116, 70–78.

Vanwalleghem, T., Amate, J.I., de Molina, M.G., Fernández, D.S., Gómez, J.A. 2011. Quantifying the effect of historical soil management on soil erosion rates in Mediterranean olive orchards. Agric. Ecosyst. Environ. 142, 341–351.

Viceto, C., Cardoso Pereira, S., Rocha, A. 2019. Climate Change Projections of Extreme Temperatures for the Iberian Peninsula. Atmosphere, 10, 229. https://doi.org/10.3390/atmos10050229.

5 Annual Cropping Central Europe: Brandenburg, Germany

Bayer, Lukas; Bandru, Keerthi; Helming, Katharina

5.1 Regional Information

The study focus area is the state of Brandenburg, which is located in north-eastern Germany and covers 29.640 km2. It is an excellent case study to represent modern agriculture in Europe, because it is an agricultural state characterized by intensive use; approximately 45% of its area is dedicated to intensive agricultural land use. Refer Table 5-1 for additional information. Compared to other German states, Brandenburg shows a relatively high share of organic agriculture (12% of the agricultural area), and this share is continuously increasing (Ministerium für Landwirtschaft, Umwelt und Klimaschutz (MLUK), 2019; Wolff et al. 2020).

Extreme changes in soil functions with large-scale effects have occurred over the last 150 years due to industry, settlement and traffic. In the lignite mining areas, for example, tipping areas with extremely acidic parent rock were created and thus completely new conditions for soil development. Old industrial sites, but also sewage fields, show heavily altered soils damaged by substance inputs. Settlement and traffic areas are considerably impaired in their properties by sealing. In total, soils with the above-mentioned changes occupy at least 10 % of the state's area.

Brandenburg is representative for very large scale high technology and industrialized agriculture. Farm sizes are among the largest in Europe (242 ha). The area suffers from low precipitation and it is expected that climate change aggravates the situation so that farming may be economically non viable in the future. At the same time, the Berlin metropolitan region increases the demand for high quality regionally produced food, which gives an opportunity for short value chains. The threat of climate change leads to farmers eagerness to change their production system to make it resilient for future conditions. Digitalization is seen as a key measure to manage the risks and to introduce such changes by the agronomist community in the region, both in terms of management practices for soils and of consumer-producer communication (Mouratiadou et al., 2023). The challenge is to find out the impacts of the aforementioned changes to the soil health in the region, in large-scale high-tech farming systems. Farmers might change their production system, for example, to implement agroforestry, introduce direct marketing strategies, diversification of production systems (such as crops, crop rotations, value chains). Expected impacts may be higher impact due to less dependency on value chain actors, higher soil organic carbon and less erosion by implementing agroforestry, diversified cropping system and crop rotations impact positively soil health such as soil structure, nutrition balance and inhibit soil borne diseases and increase biodiversity.

Table 5-1: Regional Information of Brandenburg, Germany

Issue	High tech agriculture in combination with poor soils. Low precipitation aggravated climate change, increasing risk of drought and yield failures
Dominant land use:	High Tech Agriculture
Secondary land use:	Forestry; metropolitan region Berlin is spreading into Brandenburg
Climatic Zone	Continental
Soil WRB classification	Luvisols
Soil texture	dominantly loamy sand, sandy loam; 4% organic soils
Dominant topsoil texture	Loamy sand and sandy loam
Soil threats	SOC decline, compaction, biodiversity decline, soil erosion (water, wind, tillage); decreasing water retention capacities
Representative regions	Brandenburg represents a region in Europe with large scale, large field sizes, highly industrialized, similar to the regions around the Po Valley, Veneto, Emilia-Romagna, Lombardy, and Normandy, as well as regions in Eastern Europe as they share a common heritage of eastern block association.

5.2 Stakeholders Interaction

The Figure 5-1 shows the different categories of stakeholders interacted during the soil needs assessment workshops and interviews in the Brandenburg region. The Regional Soil Health workshop took place on the 26.5.2023 in Müncheberg, Brandenburg. Intentionally invited were a broad selection of stakeholders from Brandenburg but also from Germany, who became aware about the workshop through related Soil Mission projects (Nati00ns).

The workshop also features an excursion to experimental site patchCROP (https://comm.zalf.de/sites/patchcrop/SitePages/Homepage.aspx), a landscape experiment with high diversity of crops in a spatially limited area as part of a mosaic. The experiments address the question of how novel sensing, monitoring, small robotic and management systems can support the provision of ecosystem services in diversified cropping systems while maintaining or increasing resilience and production. The workshop was an opportunity for stakeholders in Brandenburg to come and to critically reflect about their current activities anow they will develop for the year 2030.

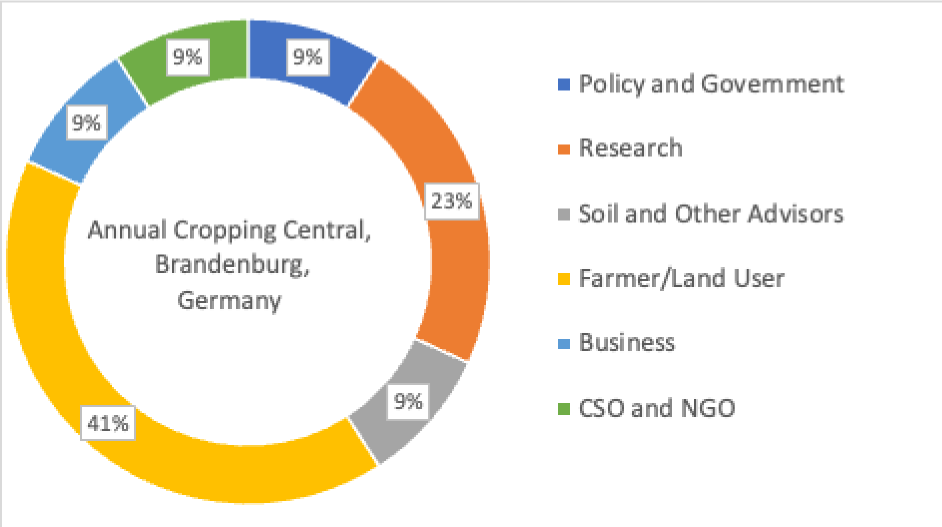


Figure 5-1: Stakeholder interaction in Brandenburg, Germany

5.3 Soil Needs Assessment

5.3.1 Drivers

Multiple biophysical drivers could be identified in Brandenburg. Several are active in the longer term, and have been active in the past. They become especially severe through climatic changes and annual extremes. Such as an expected shift of the agro-climatic zones in Europe, occurring at 25-135 km per decade in a scenario that would heat the average surface temperature 2 °C (Ceglar et al., 2019; IPCC 1844). Topographical and biophysical features which are unfavourable such as steep slopes, shallow and/or poor soils, and poor accessibility (Lüker-Jans et al. 2016) affect production levels in agriculture.

Drought Risk: Droughts and higher temperatures are likely to occur more frequently in the 2050 depending on the socio-economic scenarios seen in Figure 1. Ihlnegbu and Ogunwumi (2021) found that 77,54 % of agricultural area were affected by high drought in 2018, which leads to less water available for plants. Additionally, Brandenburg's soils are characterized by a low fertility in comparison with the rest of Germany. This circumstance is a major biophysical driver for decision-making practices of involved stakeholders. The risk for water and wind erosion is in certain areas of Brandenburg, especially to the north and north east, as well as west-south is higher than in others (Gericke et al., 2019). These areas also overlap in part with high soil fertility.

Socioeconomic driver: Large-scale agricultural land use emerged in Brandenburg after 1945, because of the disappropriation process in the Soviet Occupation Zone (Batáry et al., 2017). To date, average plot sizes in this region have remained considerably larger than elsewhere in Germany, despite restituted ownership of land during the transition process (Hartvigsen, 2014; Wolff et. al 2020).

Policies: Inadequate policies have driven the production of corn in the last decades, specifically to produce biogas (Grundmann et al., 2012; Vergara and Lakes, 2019). The socio-economic systems appears highly susceptical to policies and financial incentives. In the last decade Brandenburg has experienced an increase in photovoltaic installation for energy production, the field size is ideal for large scale installation. Heritage from the 20th century seems therefore an influential factor. For the future, one could expect that with declining population sizes in Brandenburg and a concentration of farms in fewer hands with larger overall hectares the use of large machinery owned by agribusinesses. Observations such as "land grabbing" are circulating in the press (Maurin, 2023) and small farms suffer challenges of acquiring land for their purposes.

Further identified socio-economic drivers in the literature review:

- Lack of adequate extension services and research transfer to farmers
- Export market dependent agriculture in a globalized world, leads to price pressures and dependencies on global market prices for resources (fertilizers) as well as export. (Hagedorn et al. 2011)
- Consumer demand
- Factor costs
- Policies and conditionality of the CAP (2023 – 2027, see also responses of the system) (MLUK, 2023)
- Farmers attributes (education, age, know-how, political attitudes)
- Research into soil threats and the impact on changes in soil management
- Technology (ICT) improves traceability, transparency and information on soil management impacts
- Research into Robotics and their development (more research, more development)
- Increased demand from the following categories leads to intensification of soil management: food, animal products, biomass for energy, food waste, increase industrial use of biomass. (Techen and Helming, 2017)

The aforementioned drivers, biophysical and socioeconomic, have led the agricultural production system to an intensive functioning which is predominately associated with larger plot sizes, and narrow crop rotation (maize, wheat, rey), as a result of continuous scaling in mechanization to achieve higher economic efficiency (Stoate et al., 2009; Ruiz-Martinez et al., 2015). This enabled highly efficient and intensive cropland management, including the use of heavy-duty machinery for ploughing, seeding and harvesting, enabled by lower heterogeneity and less complex habitat structure (lynchets, groves, hedges, and other typical regional landscape elements).

5.3.2 Pressures

Pressures that are desired by the participants from the workshop included numerous options:

- precision farming and an uptake of autonomous machineries
- context adapted agricultural practices (conditions in soil and weather when choosing crops)
- flexible site adapted soil management
- Soil as a crop location factor
- No-till practices
- Bio-char
- Agriphtovoltaic practices.

In combination with the pressures identified in the workshop, we consider the five pressure categories as identified in Techen and Helming (2017), apply in Brandenburg. Spatial patterns of cropping systems: distribution of fields and crops, quality of field transition zones, increased field sizes, lack of landscape elements (hedgerows, small transition zones between crops), Crops & Rotations.

Mechanical pressures: lighter, smaller and autonomous machinery may reduce; ploughing might be reinforced if the use of glyphosate is banned

Inputs into the soil: precision application – small robots for precise pesticide application, mechanical destruction of weeds, drones, (on-the-go) sensors for soil characteristics, data fusion algorithms, translation into decision-support systems, infrastructure with GNSS (global navigation satellite system), and mobile networks. Behaviour towards soil management practices by practitioners

5.3.3 State

The state of Brandenburg soils in terms of soil health for agricultural production is determined by. In the workshops these were:

- Water retention capacity in root zone depth (refer Figure 5-2)
- Insufficient water retention capacity
- Generally low and medium levels of soil organic matter (refer Figure 5-3Figure 5-4Figure 5-5)
- State of the organic carbon stock at 0,3 m

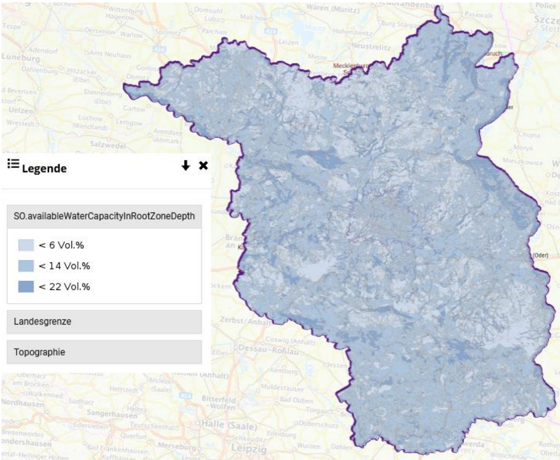


Figure 5-2:Water retention capacity in root zone depth.

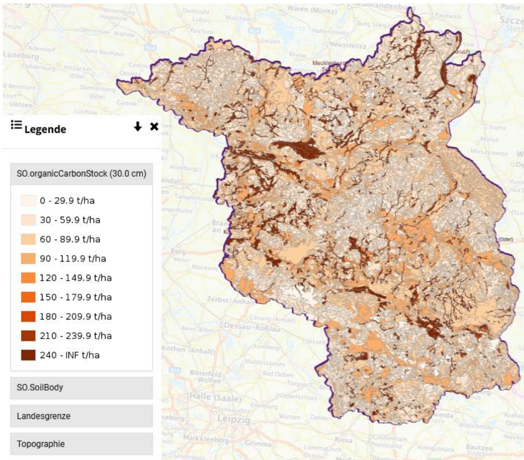


Figure 5-3:Soil organic matter classes in Brandenburg (low h1 to high h7).

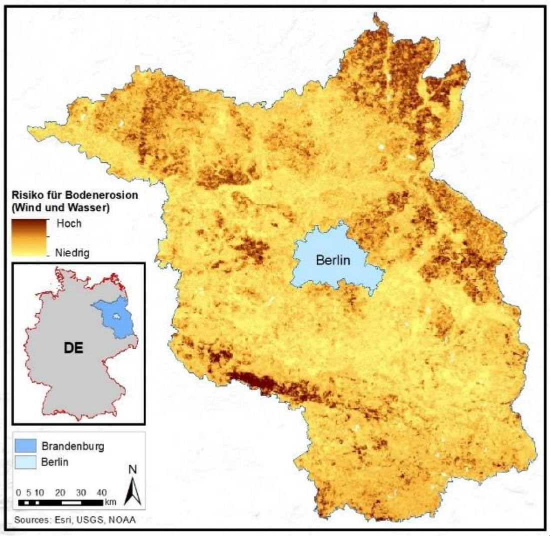


Figure 5-4:Vulnerability for wind and water erosion

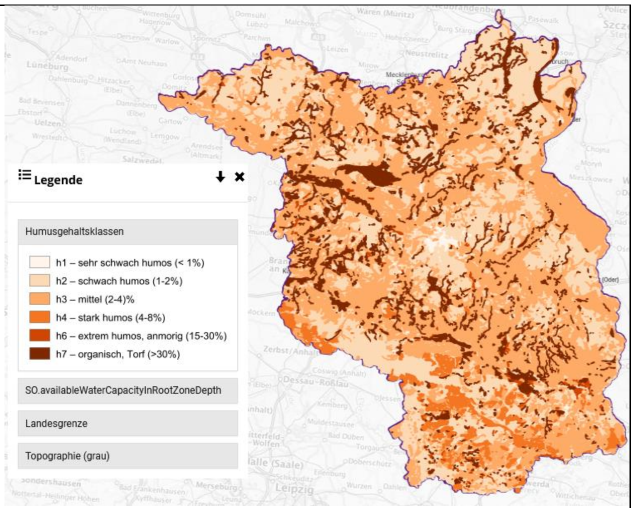


Figure 5-5:Soil organic matter classes

5.3.4 Impacts

We collected the impacts in the workshop in the discussion sessions. Participants were concerned with the ever-increasing economic vulnerability of farms finances and their land to climate change and extreme weather events. In the socio-economic part of the system, price shocks from world trade (Hagedorn, 2011) and the dependency on cap payments represented the biggest impacts on socio-economic viability of the farming activity, with decreasing returns. Unforeseeable dynamics of the CAP´s expansion of the second pillar and the changes, worried many participants as their planning capacity is severally impacted, leading them to consider moving out of the farming sector. Eco-system services are also impacted negatively and have through the large scale farming activity seen a decrease, especially in soil organic matter and soil fertility.

5.3.5 Response

Soil management practices should be adapted so that the water rentention capactiy of soils may be increased or stabilized, by implementing no-till and increasing better soil structures. Specific micro-climates on an landscape level should be considered to adapt to different climate conditions. Additionally, a diversified product portfolio may offer an adaptation strategy, which can also meet changing societal consumption preferences and diets. Furthermore, a diversified product portfolio could protect against price shocks, when a price of a crop comes drops unexpectedly due to external influences. This may occur when a adapted value chain forms, primary products which are processed into food may provide one source of income. Reconnecting the urban-rural linkages is of special relevance in this regard for Brandenburg as Berlin is in its center (Zasada, 2012; Fries, 2020; Vincente-Vincente et al., 2023)

As a response to the lack or limitations of the knowledge transfer and diffusion in the privatized agricultural extension service (Münchhausen; Häring, 2012). The Climate change Adaptation Brandenburg Berlin Network was created and ran until 2015. The aim was to ensure the sustainability of the land and water use in Brandenburg. However, this response failed with the end of the project, highlights the need for continuing activity. Joint learning processes were in the forefront and knowledge on climate change is distributed and show the need for such as system.

Digitalization: Closely related to knowledge sharing platforms are activities such as the Digital Agricultural Knowledge and Information System (DAKIS), assigning new roles to advisors, such as facilitator and intermediaries and the role of digitalization in agriculture (Mouratiadou et al., 2023). Innovation activities should focus on the one hand on the knowledge transfer system in Brandenburg, as it has been described as severally impacted after reunification.

Adaptation activities to climate change should move to the forefront as well. Especially measures that limit erosion should be focused on, such as no-till practices or agroforestry. A change in spatial patterns may also lead to smaller field sizes, reducing the risk of the temptation to use large farming machines, affecting compaction. Changing spatial patterns is already foreseen in the current CAP period (see conditionality in responses).

The reestablishment of regional supplies could also stabilize the system and increase resilience to the risk of price shocks by the international trade system. The large dependency on corn as the main crop for biogas could also be reduced by establishing separate income sources.

Land grabbing poses the most recent threat to soils in Brandenburg, as financial investors have bought up large areas of land, their ambition and managing decision however are not transparent and difficult to estimate.

Concluding, the farming system in Brandenburg and its focus on efficient production in large field sizes will increasingly rely on digitalisation and robotics. This is made possible by large agricultural enterprises who have the financial capital for investment. Nonetheless, this future is one of many depending on the political framing conditions of the future, smaller scale farming may become more prominent again. At the moment the system is still effected by its past decisions and strong path dependency due to field and farm structure. The circumstances limit self-determination and effect management decisions of today, especially in terms of spatial organisation.

5.4 References

IPCC. Intergovernmental Panel on Climate Change. 2022 contribution by Pörtner H, C.; Robers, D.C., Tignor, M., Poloczanska E.S.[…] etc. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 1817–1927, doi:10.1017/9781009325844.015.

Deutscher Wetterdienst (2020) Local weather and climate data of Berlin and Brandenburg. https://www.dwd.de/EN/weather/weather_climate_local/berlin-brandenburg/bbb_node.html. Accessed 15 February 2021.

Daedlow, K., Lemke, N., Helming, K., 2018. Arable Land Tenancy and Soil Quality in Germany: Contesting Theory with Empirics. Sustainability 10 (8), 2880. 10.3390/su10082880.

Diehl, K.E., Bachinger, J., Hamadeh, S.K., 2015. Requisite Variety in Adaptation Strategies: Case Studies from Two Regions Prone to Climate Change, Brandenburg, Germany and Semi-arid Bekaa, Lebanon. Procedia Environmental Sciences 29, 132–133. 10.1016/j.proenv.2015.07.223.

Dimter, S., Knierim, A., Nage U. W. Farmers' use of Brandenburg's privatized extension. Presented at the 8th European IFSA Symposium, 6 – 10 July 2008, Clermont-Ferrand, France.

Drastig, K., Suárez Quiñones, T., Zare, M., Dammer, K.-H., Prochnow, A., 2019. Rainfall interception by winter rapeseed in Brandenburg (Germany) under various nitrogen fertilization treatments. Agricultural and Forest Meteorology 268, 308–317. 10.1016/j.agrformet.2019.01.027.

Doenmez, C., Schmidt, M., Cilek, A., Grosse, M., Paul, C., Hierold, W., Helming, K., 2023. Climate change impacts on long-term field experiments in Germany. Agricultural Systems 205, 103578. 10.1016/j.agsy.2022.103578.

Fries, J. 2020. The Other Side of the Table: the Countryside's role in the Brandenburg-Berlin Food System.

Gutzler C, Helming K, Balla D, Dannowski R, Deumlich D, Glemnitz M, Knierim A, Mirschel W, Nendel C, Paul C, Sieber S, Stachow U, Starick A, Wieland R, Wurbs A, Zander P. 2015. Agricultural land use changes - a scenario-based sustainability impact assessment for Brandenburg, Germany. Ecological Indicators 48:505-517. DoI 10.1016/j.ecolind.2014.09.004

Gericke, Kiesel, Deumlich, Venohr, 2019. Recent and Future Changes in Rainfall Erosivity and Implications for the Soil Erosion Risk in Brandenburg, NE Germany. Water 11 (5), 904. 10.3390/w11050904.

Grundmann, P., Ehlers, M.-H., Uckert, G., 2012. Responses of agricultural bioenergy sectors in Brandenburg (Germany) to climate, economic and legal changes: An application of Holling's adaptive cycle. Energy Policy 48, 118–129. 10.1016/j.enpol.2012.04.051.

Hagedorn, K., 2011. Die Landwirtschaft in Brandenburg unter dem Einfluss der Globalisierung: Diskussionspaper 13.

INSPIRE. 2023a. View Service: Soil / Kennwerte der Wasserbindung Brandenburg (WMS-SO-BOBINDUNG): https://geoportal.brandenburg.de/detailansichtdienst/render?view=gdibb&url=https%3A%2F%2Fgeoportal.brandenburg.de%2Fgs-json%2Fxml%3Ffileid%3D2aaa756d-b0b0-46c3-a5b9-503afe0b91c4

INSPIRE. 2023b. View Service: Soil / Kohlenstoffvorräte im Boden Brandenburg (WMS-SO-CVORR) https://geoportal.brandenburg.de/detailansichtdienst/render?view=gdibb&url=https%3A%2F%2Fgeoportal.brandenburg.de%2Fgs-json%2Fxml%3Ffileid%3De2478c9e-97b5-44f3-a610-27dac1f362f5

INSPIRE. 2023c. View Service: Soil / Humusgehaltsklassen (nach KA5) im Oberboden des Landes Brandenburg (WMS-SO-HUMUS). https://geoportal.brandenburg.de/detailansichtdienst/render?view=gdibb&url=https%3A%2F%2Fgeoportal.brandenburg.de%2Fgs-json%2Fxml%3Ffileid%3D595ed7f7-4942-43d6-854b-74736f62ee65

INSPIRE. 2023d. View Service: Soil / Verdichtungsempfindlichkeit im Oberboden in Brandenburg (WMS-SO-

VERDICHT).https://geoportal.brandenburg.de/de/cms/portal/start/geosearch/e2478c9e-97b5-44f3-a610-27dac1f362f5#

Ihinegbu, C., Ogunwumi, T., 2022. Multi-criteria modelling of drought: a study of Brandenburg Federal State, Germany. Model. Earth Syst. Environ. 8 (2), 2035–2049. 10.1007/s40808-021-01197-2.

Kipping, K. (2020) Climate change—regional vulnerability analysis for the Federal State of Brandenburg. A sector-specific perception of adaptation strategies and action recommendations. Universität Potsdam. https://www.uni-potsdam.de/fileadmin/projects/geographie/Regionalwissenschaft/Projekte/Climate_Change_-_Regional_Vulnerability_Analysis_for_the_Federak_State_of_Brandenburg.pdf.

Knuth, U., Knierim, A., 2014. How to strengthen the link between advisors and research in a privatized advisory system? – The case of Brandenburg, Germany.

Landesregierung Brandenburg. 2023a. Agrarstruktur im Vergleich, https://agrarbericht.brandenburg.de/abo/de/start/agrarstruktur/im-vergleich/, accessed 1 July 2023

Landesregierung Brandenburg. 2023. Klimawandel im Land Brandenburg deutlich messbar. https://lfu.brandenburg.de/lfu/de/aufgaben/klima/klimawandel/klimawandel-deutlich-messbar/ accessed 15 July 2023.

Maurin, J., (1.3.2023). Landgrabbing in Brandenburg. Agrarbetrieb geht an Immobilienhai. Taz. Accessed on 7.6.2023 from https://taz.de/Landgrabbing-in-Brandenburg/!5915997/.

Mueller, L., Schindler, U., Behrend, A., Eulenstein, F., Dannowski, R. The Muencheberg Soil Quality Rating (SQR): field manual for detecting and assessing properties and limitations of soils for cropping and grazing.

Münchhausen, S. von, Häring, A., 2012. Lifelong learning for farmers: Enhancing competitiveness, knowledge transfer and innovation in the eastern German state of Brandenburg. stagec 114 (2), 86–92. 10.7896/j.1217.

Ministry for rural development, environment and consumer protection (MLUK). 2020. Böden. Steckbriefe Brandenburger Böden – Sammelmappe.

Ministry for rural development, environment and consumer protection (MLUK). 2023. Konditionalität (2023 until 2027). Accessed from: https://mluk.brandenburg.de/mluk/de/landwirtschaft/agrarpolitik/neue-gap-foerderperiode-ab-2023/konditionalitaet/

Ministry for rural development, environment and consumer protection (MLUK). 2023. Agrarstrukturgesetz accessed from https://mluk.brandenburg.de/mluk/de/ueber-uns/agrar-und- umweltpolitik/agrarstrukturgesetz-in-vorbereitung/

Mouratiadou, I., Lemke, N., Chen, C., Wartenberg, A., Bloch, R., Donat, M., Gaiser, T., Basavegowdae, D.H., Helming, K., Hosseini Yekani, S.A., Krull, M., Lingemann, K., Macpherson, J., Melzer, M., Nendel, C. Piorr, A., Shaaban, M., Zander, P., Weltzien, C., Bellingrath-Kimura, S.D. (2023). The Digital Agricultural Knowledge and Information System (DAKIS): employing digitalization to encourage diversified and multifunctional agricultural systems. Environmental Science and Ecotechnology 16:100274. https://doi.org/10.1016/j.ese.2023.100274

Plieninger, T., Bens, O., Hüttl, R.F. Innovations in land-use as response to rural change – a case report from Brandenburg, Germany.

Prager, K., Hagemann, N., Schuler, J., Heyn, N., 2011. Incentives and enforcement: The institutional design and policy mix for soil conservation in Brandenburg (Germany). Land Degrad. Dev. 22 (1), 111–123. 10.1002/ldr.1038.

Preissel, S., Zander, P., Knierim, A., 2017. Sustaining Farming on Marginal Land: Farmers' Convictions, Motivations and Strategies in Northeastern Germany. Sociologia Ruralis 57, 682–708. 10.1111/soru.12168.

Raab, T., Raab, A., Nicolay Alexander, Takia, M., Hirsch, F., Schneider, A., Rösler, H., Bönisch, E., 2014. Human-induced landscape dynamics in South Brandenburg - findings from different geoarchives.

Reyer, C., Bachinger, J., Bloch, R., Hattermann, F.F., Ibisch, P.L., Kreft, S., Lasch, P., Lucht, W., Nowicki, C., Spathelf, P., Stock, M., Welp, M., 2012. Climate change adaptation and sustainable regional development: a case study for the Federal State of Brandenburg, Germany. Reg Environ Change 12 (3), 523–542. 10.1007/s10113-011-0269-y.

Rivera, W., Alex, G. Volume 2. Privatization of Extension Systems - Case Studies of International Initiatives. Agriculture and Rural Development Discussion Paper 9. 2004.

Sattler, C., Nagel, U.J., Werner, A., Zander, P., 2010. Integrated assessment of agricultural production practices to enhance sustainable development in agricultural landscapes. Ecological Indicators 10 (1), 49–61. 10.1016/j.ecolind.2009.02.014.

Schaal, U. DGWF2012_Mnchhausen_Rieken_Hring.

Scholz, S., Bloch, R., Münchhausen, S. von, Häring, A.M. "Cropping School" - An alternative to advisory services in Brandenburg, Germany? 13th European IFSA Symposium, 1-5 July 2018, Chania (Greece).

Schuler, J., Sattler, C., 2010. The estimation of agricultural policy effects on soil erosion—An application for the bio-economic model MODAM. Land Use Policy 27 (1), 61–69. 10.1016/j.landusepol.2008.05.001.

Seserman, D.M., Veste, M., Freese, D., Swieter, A., Langhof, M. BENEFITS OF AGROFORESTRY SYSTEMS FOR LAND EQUIVALENT RATIO CASE STUDIES IN BRANDENBURG AND LOWER SAXONY, GERMANY. 4th European Agroforestry Conference Agroforestry as Sustainable Land Use.

Helmholtz Centre for Environmental Research (UFZ). 2023. Drought Monitor Germany. Accessed on june 21st 2023 from: https://www.ufz.de/index.php?en=37937

Vergara, F., Lakes, T., 2019. Maizification of the Landscape for Biogas Production? Humboldt-Universität zu Berlin.

Vicente-Vicente, J. L., Borderieux, J., Martens, K., González-Rosado, M., Walthall, B. (2023) Scaling agroecology for food system transformation in metropolitan areas: agroecological characterization and role of knowledge in community-supported agriculture farms connected to a food hub in Berlin, Germany. Agroecology and Sustainable Food Systems 47, 6, 857-889

Zasada, I. 2012. Peri-urban agriculture and multifunctionality: urban influence, farm adaptation behaviour and development perspectives.

6 Wine Farming: Bordeaux vineyard, France

Lisa Viry (Acta), Flavien Poinçot (Acta)

6.1 Regional Information

The area dedicated to vineyards (currently 7.3 million ha) has been slightly declining for several years at the global level (OIV, 2023). In Europe, this surface has been stable at 3.3 million ha (45% of the world total) for the last seven years, and in France, vineyards are expanding slightly each year, with a total area of 797,000 ha in 2020, ranking second behind Spain (961,000 ha). However, the crisis in the sector is leading the actors in Bordeaux to consider reducing the size of their vineyards as part of a grubbing-up plan proposed by the public authorities to address the situation. Refer Figure 6-1 and Table 6-1 for the regional information.

Numerous soil studies since the 1970s have highlighted the wide diversity of soil types in the Gironde wine-growing area (Bois and Van Leeuwen, 2008). Compared with other crops, wine-growing soils are generally recognized as having low levels of organic matter (Gis Sol, 2011, INRA, 2020). These soils, while not very suitable for most crops, can encourage the growth of smaller and juicier grapes, which will generate more concentrated and flavored wines, although at lower yields.

Climate change disrupts long-established patterns of temperature and precipitation in wine-growing regions and causes more extreme weather events, which could have serious impacts on terroir and the wine industry. A lack of water at the right time may cause benefits by forcing the development of the grapes instead of the leaves and canopies. However, hotter temperatures and an earlier growing season can also push berries towards undesired property changes, such as a higher sugar content, lower acidity, and differences in secondary compounds that are important for aromas.

Due to the nature of the soil and agricultural activities, wine-growing areas generally face the challenge of soil impoverishment. For the Bordeaux region, the main issues identified relating to soil health in the territory are artificialization, erosion, compaction, pesticide and copper pollution, and loss of biodiversity.

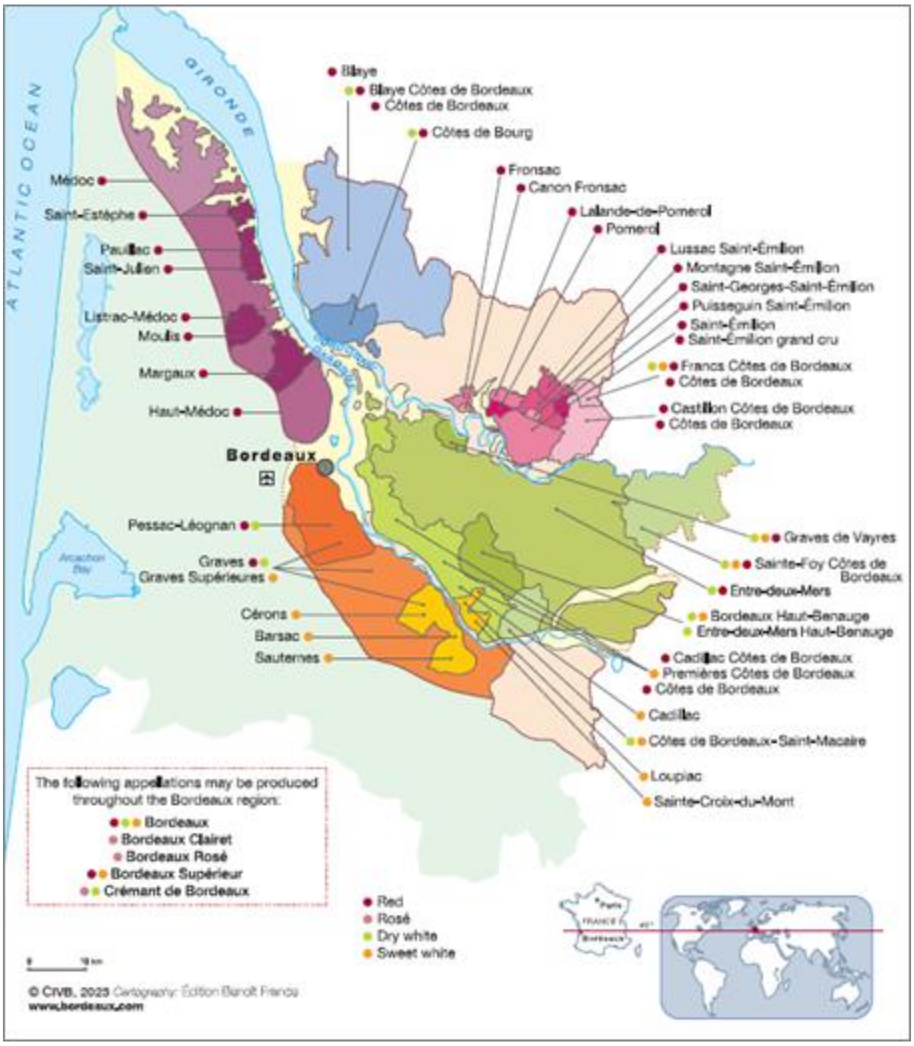


Figure 6-1:The Bordeaux Vineyard, France

Table 6-1:Reigonal Information Bordeaux Vineyard, France

Dominant land use	Agriculture: wine growing, cereals, grassland, fodder
Secondary land use	Urban and peri-urban
Climatic Zone	Oceanic climate
Soil WRB classification	Mainly Cambisols, Gleysols, Luvisols, Podzols
Soil texture	Mainly Sandy loam, silt-clay, graves
Soil threats	Erosion, soil sealing, compaction, biodiversity decline
Representative for regions :	Can be representative of other vineyards near the Atlantic coast. Based on its specific climate, part of the vineyard can be representative for some regions in the north of Spain, in the North of Portugal and in some parts of Italy.

6.2 Stakeholder Interaction

The Figure 6-2shows the different categories of stakeholders interacted during the soil needs assessment workshops and interviews in the Aquitaine region.The Soil Needs Assessment Workshop took place on April 26th at Maison de l'Agriculture et de la Forêt in Bordeaux, France. 15 local stakeholders participated in this event. 10 interviews with local stakeholders were organized between December 2022 and May 2023. Some interviews gather several stakeholders from the same organizations. In total, 27 stakeholders from 12 organizations were involved, either during the workshop or during interviews. Stakeholders are identified as the main category for which they were involved in our evaluation. However, it is worth noting that due to their activities, they could have input relevant for other stakeholder categories, such as some stakeholders from research who also have activities related to higher education or vocational training.

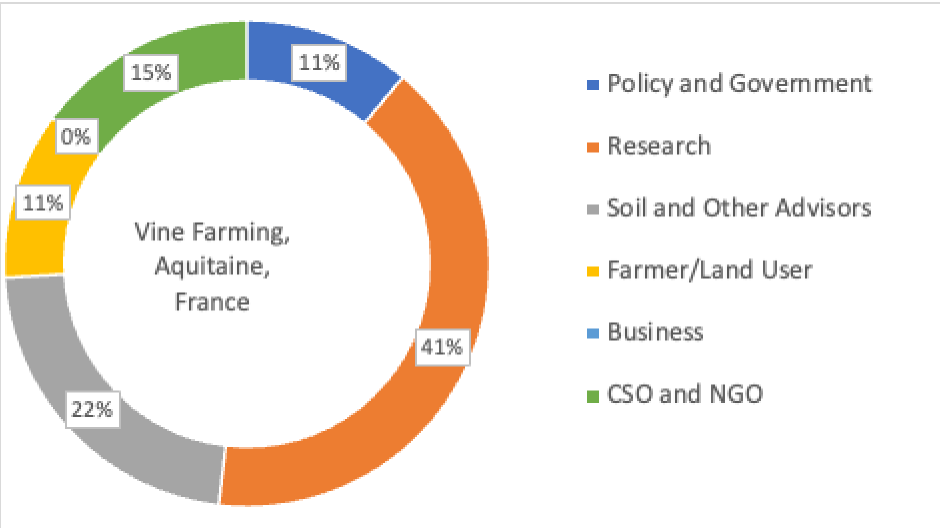


Figure 6-2: Stakeholder interaction in Aquitaine, France

6.3 Soil Needs Assessment

6.3.1 Drivers

Biophysical drivers: Climate plays a key role in vine growth and grape ripening (Bois, 2007; Ollat et al., 2016; Van Leeuwen et al., 2022). Gironde has an **oceanic climate—a** warm temperate climate with moderate summers and no dry season (Bois, 2007). However, there is **significant climatic variability** within the vineyard, with a thermal gradient from the north-west to the south-east of the area, the latter having a more marked continental climate. Temperatures measured across the Gironde wine-growing region show differences of up to 1°C on average during the vine-growing season. Several environmental factors explain this, such as the proximity of the Atlantic Ocean and the Gironde estuary, as well as the urban heat island effect for vineyards close to urban areas. This variability and the diversity of soil types in the vineyards give the different terroirs in the region their own specific character (Bois, 2007; Blois and Van Leeuwen, 2008).

The climate of the Bordeaux vineyards is now evolving due to **climate change**. The **increase in temperatures** between 1959 and 2016 was around 1.4°C in New Aquitaine (AcclimaTerra, 2018). In the future, the climate is likely to continue to evolve, with temperature rises varying in magnitude depending on the scenario. **Precipitation patterns** could also change, with significant variability among regions and seasons (IPCC, 2022). **The frequency and intensity of extreme events,** including extreme heat, intense precipitation, storms, and heatwaves, will increase globally and in New Aquitaine (IPCC, 2022; AcclimaTerra, 2018). The same applies to droughts in agricultural soils: between 1959 and 2016, 6% more areas were affected by **agricultural droughts** in New Aquitaine (AcclimaTerra, 2018). The Bordeaux vineyards have recently experienced a succession of climatic accidents, with late frosts (2017, 2020, 2021, 2022), hail (2022, 2023), and drought (2022). According to France's leading farming union, the late frosts in 2021 caused damage estimated to be worth at least two billion euros in France (AFP, 2021).

Analysis of the interviews shows that **climate change is seen as a major issue** by the stakeholders that are well aware of the effect it can have on the vines. In the long term, **some projections predict the need to move existing vineyards** to areas with a more favorable climate, even for a scenario of a global rise in temperature at +2°C compared to the pre-industrial era (Hannah & al., 2013; Sgubin & al., 2023).

Finally, on a national scale, **vine decline** is a process with multiple causes (biological, physical, or linked to cultivation practices) and is responsible for the drop in yield and vine mortality. The average rate of unproductive vines in the vineyard is estimated at 11%, leading to an annual yield loss of 4.6 hl/ha (BIPE, 2015). To monitor the phenomenon and take concerted action at all levels, the government and the wine industry launched the National Vineyard Decline Plan in 2015.

Socioeconomic driver/issue: The winegrowing industry in Bordeaux is facing significant economic challenges. While 55% of Gironde wine is sold on the domestic market, French wine consumption is falling, particularly red wine. Sales of Bordeaux wine fell below the 2.5 million hl mark in France in 2018 (Agreste, 2020). This decline has not been offset by exports, due to the **increase in international competition**.

Stakeholders interviewed highlighted the phenomenon of "*Bordeaux bashing*" to explain the decrease in demand at the national level: consumers criticize the region's wines due to perceptions of an outdated image, unappealing prices, or the use of certain inputs.

These various trends have led to overproduction in the Bordeaux region. Out of the 3.8 million liters produced in Bordeaux in 2022, 500,000 hectoliters are being stored or sold at unprofitable prices. In a survey conducted in 2023 by the Gironde Chamber of Agriculture, 1,320 winegrowers, accounting for over 30% of winegrowers in Gironde, reported **financial difficulties**, highlighting the **decline in winegrowers' incomes**. On April 17, 2023, the Bordeaux Wine Bureau voted in favor of a **plan to remove 9,500 hectares of vineyard**. To compensate for these economic losses, more winegrowers are diversifying their activities (Gironde Chamber of Agriculture, 2023) or embracing **wine tourism** by opening their vineyards to visitors.

In terms of changes in the wine industry, **the number of winegrowing holdings in Gironde fell by 24% between 2012 and 2022**, while the surface area of the Bordeaux vineyard remained stable. This can be explained by the retirement of winegrowers and the economies of scale achieved when vineyards are enlarged. The "Sempastous" law, adopted in December 2021, aims to regulate access to agricultural land and thus attempt to moderate this type of land concentration dynamic.

However, these observations contrast with very diverse realities. Some stakeholders describe a **"two-speed vineyard"**, both in terms of selling prices and agricultural land, and highlight that some winegrowers are unable to change their practices because of reduced financial capacity. The workload is becoming heavier, while labor shortages are becoming a recurring problem. In the context of a Living Lab, it may be difficult to represent all the profiles, as investment capacity varies from one farm to another.

Demographic dynamics are also increasing the pressure of urbanization on wine-growing areas. In Gironde, the number of inhabitants has increased by an average of 1.2% each year between 2014 and 2020, compared with an average of 0.3% nationally (Insee, 2023). This growth is mainly due to the **attraction of the Bordeaux metropolitan area**. As a result, the housing stock is expanding in Bordeaux and the surrounding area, and it is in close proximity to major transport routes. The **search for amenities** is contributing to the **urban sprawl** of agricultural areas (Péres, 2009). To a certain extent, territorial planning can protect agricultural areas from urban expansion. However, agricultural stakeholders are not systematically involved in the process of establishing planning documents, and their role is mainly consultative (Duvernoy et al., 2005). Territorial planning has recently evolved with the introduction into French law of a target of “no net land take” by 2050 and the requirement for local authorities to gradually reduce the rate of net land artificialization.

The societal demand for a healthy environment and sustainable agriculture is also a concern for the industry stakeholders interviewed. The Bordeaux vineyard is the leading region in terms of certified Demeter and organic agriculture surfaces. However, the prices of organic wines struggle to offset the additional costs associated with certification (France Agri Mer, 2014), and support for maintaining organic agriculture is declining (HCC, 2022).

6.3.2 State

Le Bissonnais et al. (2002) stated that in Aquitaine, the risk of erosion in vineyards exists but remains relatively low (except in winter). Vine-growing is not the main factor in triggering erosion, although it can locally exacerbate susceptibility to run-off. Specific agricultural practices are known to exacerbate these natural phenomena: plowing slopes, bare soil in winter, low-coverage crops, etc. According to the AcclimaTerra report, based on the data from the Gis Sol, the wine-growing regions of Entre-Deux-Mers, Côtes du Bordelais, and Landais face high erosion risk. With the evolution of rainfall patterns due to climate change, the erosive risk could increase in the future (Smetanová et al., 2019).

Regarding **pesticide residues in the vineyard soils**, a 2019 EU-wide study revealed that 50% of soil samples collected from vineyards in south-western France contained between 2 and 5 residues of the 76 pesticides studied with concentrations between 50 and 150 ng/g (Silva et al., 2019). Research carried out on 27 vineyard plots in the Blayais region also shows that all plots present pesticide residues in their soil. **63 organic molecules** (32 fungicides, 18 insecticides, and 13 herbicides) and **copper** were identified, including 11 from pesticides banned since 2008 (Pierdet, 2020). Three metabolites of banned molecules were also found.

Copper concentrations vary considerably within the Bordeaux vineyards, from low concentrations (between 0,62 and 8,02 mg/kg) to very high concentrations (between 23,17 and 94,43 mg/kg) in some areas (AcclimaTerra, 2018). According to the meta-analysis by Karimi et al. (2021), the toxicity of copper on soil biodiversity is observed at doses 50 times higher than those authorized for viticulture per year (4 kg Cu/ha). However, the accumulation of copper observed in the superficial layers of the soil (up to 10 cm deep) can lead to concentrations high enough to affect the soil microfauna and microflora (above 50 mg/kg). This accumulation can also be problematic in the event of a change in land use (Gis Sol, 2011).

Gis Sol (2011) revealed that **lead concentrations** exceeding 50 mg/kg were detected in the Bordeaux region, whereas 95% of values in France are lower. This may be due to the past use of lead arsenates to treat vines, now banned (Gis Sol, 2011).

As vineyards are often set on soils that would not be adapted to other crops, with initially low levels of organic matter (Gis Sol, 2011, INRA, 2020), it is not surprising that vineyards in France are characterized by **low soil carbon levels**, with values of the order of 0.5–1% (Meersmans et al., 2012). This is also true for the vineyards of Bordeaux, which show the lowest levels of carbon content in the Nouvelle-Aquitaine region (AcclimaTerra, 2018).

Microbial biomass is generally low in vineyard soils compared with other crops (Gis Sol, 2011). A recent meta-analysis shows that wine-growing soils have lower microbial and earthworm biomass, a lower diversity of fungi, nematodes, and micro-arthropods than other crops, but a higher abundance of micro-arthropods (Karimi, 2020).

6.3.3 Impacts

Workshop participants identified biodiversity loss as the most important problem affecting soil health, reflecting the interest of the Bordeaux wine industry in this issue. The effects of climate change, compaction, and the use of pesticides were ranked 2nd, 3rd, and 4th, respectively. Ecosystem services that can be affected by the degradation of the soils in the Bordeaux vineyards are:

- Capacity of the soil to **supply water and minerals to the vines**.
- **Regulation services** relating to **soil biological activity** and **weed control** For example, plant cover can have a positive impact on microbial biomass and soil biological activity (Steenwerth & Belina, 2008).
- **Supply services**, specifically the yield and quality of grape production. In the Libourne region, a study comparing degraded and non-degraded soils showed a significant 47% difference in production per vine, along with grapes that exhibited higher levels of anthocyanins, polyphenols, and sugar content (Fulchin et al., 2018).
- Carbon sequestration in the soil
- Bordeaux's vineyards possess a unique cultural identity and cultural significance, to which the concept of terroir refers. The vines shape the Bordeaux region's landscape and are a powerful tool for wine promotion. It contributes to the growth of wine tourism and features in the development strategies of local authorities. Landscape considerations are also entwined with changes in infrastructure and vineyard areas, involving practices such as grass cover, hedge planting, and agroforestry.
- The economic consequences of degraded soil are both direct and indirect. The impact on production involves direct economic losses, while improving or restoring the biological functioning of a soil has an implementation cost because of the equipment, the price of seeds, and the work to be carried out.

It should be noted that some practices favorable to soil preservation can raise new challenges, such as potential competition for water and nutrients. This aspect is often mentioned as a source of concern for stakeholders in relation to the implementation of cover crops and grass cover.

6.3.4 Response

Agroecological transition has been an important topic in France and in the Bordeaux Vineyard for several years. Several initiatives have been launched at the national and regional level to encourage the emergence of collective dynamics for the implementation of practices with an environmental and economic impact, such as the creation of economic and environmental interest groups (GIEE) or the set-up of several territorial innovation laboratories within the Vitirev project. Thus, most sustainable practices, such as soil tillage reduction and permanent soil cover, are well identified by the stakeholders interviewed and participants in the workshop.

One of the main levers for improving the carbon content of wine-growing soils is grass cover (Pellerin et al., 2020). In 2019, **81% of Bordeaux wine-growing soils were under permanent grass cover** (Agreste, 2022). To improve carbon levels in Bordeaux vineyard soils, grassing under the rows and the choice of cover crops are two of the main remaining levers identified during the workshop. Soil cover also helps to improve water infiltration, limit evaporation, reduce the risk of erosion, and boost biological activity in the soil. These measures can be complemented by other agro-ecological practices such as agroforestry, hedge planting, etc. Developing and using adapted and resilient rootstocks is also seen as an important lever, as it reduces the interventions required on the vines after plantation.

Although well identified, these practices have not been implemented in all the vineyards yet. Several reasons can explain that:

- Farmers don't necessarily have the capacity to take **economic risks or to face the increase in the agricultural and administrative workload** in a context where labor is in short supply.
- There is an opposition between production models within the vineyard (interviews; Villain, 2021).
- There is still a need to **optimize sustainable practices, adapt them to each terroir,** and offer tools that are **operational at the farm and plot levels**.
- Implementing these practices requires more **technical and individual support** and a strong **dissemination effort** of the tools, research results, and data already available to capitalize on what already exists (workshop).

- More broadly, a need to **raise awareness on soil issues** among all stakeholders and citizens was identified in the workshop.
- The need to **internalize soil issues within the organizations** was also highlighted: the skills are not always available within the organizations, which has an impact when it comes to developing public policies or for the consultancy sector.
- Some stakeholders pointed out that the actual governance and decision-making process may not involve local stakeholders enough. The scale of cooperatives, or ODG (defense and management bodies), could be better placed to bring about change by taking account of local characteristics.

Therefore, solutions to foster the adoption of sustainable practices could be:

- Strengthening **research and development activities** and fostering the development of experimental and **demonstration sites under real conditions**, as stated by workshop participants. This hope for research and development was identified in a wider study targeting French wine industry stakeholders (Ollat et al., 2021). As **peer-to-peer exchanges are decisive in decision-making and adoption of new practices** (interviews; Villain, 2021), increasing the number of experimental and demonstration sites would have the advantage of avoiding over-soliciting a few growers.
- Adapted **legal instruments**, although their effectiveness lies in the local acceptance of measures and their effective application.
- **Incentives,** such as funding or tax breaks for the adoption of certain practices via environmental labeling (for example, €2,500 in tax credits for all vineyards awarded the HVE label have been included in the government's 2020 recovery plan), or remuneration for ecosystem services (interviews)
- Identifying ways to bring the decision-making process closer to the field

6.4 Conclusions

The main challenges to soil health identified in the Bordeaux vineyards are artificialization and urban sprawl, erosion, compaction, loss of organic matter, and soil pollution. The loss of soil biodiversity was identified as "*the most important soil health problem*" by the stakeholders present at the workshop, ahead of the effects of climate change. Stakeholders in the Bordeaux wine industry agreed, however, that ensuring a sustainable economic situation for the stakeholders should take priority. Nevertheless, sustainable soil management was identified as a lever for improving economic resilience as well as the vineyard's ability to adapt to climate change.

Research and development, including **co-creation approaches** and **experimentation under real conditions, as well as legal and economic tools,** are the main levers proposed to preserve or improve soil health in vineyards. Some stakeholders also highlight the need for discussions to identify ways to bring decision-making closer to the field.

The region already has experience in co-creation schemes with the VitiReV territorial innovation laboratories (LIT). These laboratories involve many players in issues relating to plant protection products and reduction of pesticide use, but to date they have not included any specific research into soil. Some stakeholders are proposing that soil issues be integrated into one of the LITs, which aims to produce knowledge on the functioning of winegrowing landscapes, optimize ecological processes, and preserve biodiversity. In addition, the relationship between soils and frost, root development, soil biodiversity, and the interaction between soil microbiome and plants are just some of the issues mentioned by stakeholders as areas in which they would like to develop knowledge.

6.5 References

AcclimaTerra, Le Treut, H (dir.). (2018). Anticiper les changements climatiques en Nouvelle-Aquitaine. Pour agir dans les territoires. Éditions Région Nouvelle-Aquitaine, 250-279.

Agreste, « La filière viti-vinicole girondine au premier rang national de la viticulture d'appellation », Fiches filière, n°7, 2020.

Agreste, L'agriculture, la forêt, la pêche et les industries agroalimentaire, Graph'Agri, 2022.

AFP (2021). Gel. Au moins 2 milliards d'euros de manque à gagner pour la viticulture. https://www.geo.fr/environnement/gel-au-moins-2-milliards-deuros-de-manque-a-gagner-pour-la-viticulture-fnsea-204442 (last update 15/04/2021).

Bois B. (2007). Cartographie agroclimatique à meso-echelle : méthodologie et application a la variabilite spatiale du climat en gironde viticole. Conséquences pour le développement de la vigne et la maturation du raisin. Bioclimatologie. Université Sciences et Technologies - Bordeaux I.

BIPE (2015). Les dépérissements du vignoble. Séminaire du 22/07/2015 à la Maison de la Chimie.

Bois B., van Leeuwen C. (2008). Variabilité climatique dans la zone de production des vins de Bordeaux. Journée technique des terroirs viticoles, Ecole Nationale des Ingénieurs des Travaux Agricoles de Bordeaux (ENITAB). Dec 2008, Talence, France. 6 p. hal-02817769

Crozier M., Friedberg E. (1977). L'acteur et le système. Editions du Seuil, Paris.

Duvernoy I., Jarrige F., Moustier P., Serrano J. (2005). Une agriculture multifonctionnelle dans le projet urbain : quelle reconnaissance, quelle gouvernance?. *Les Cahiers de la multifonctionnalité, 8*, 87-104.

France Agri Mer, Plan stratégique sur les perspectives de la filière vitivinicole à l'horizon 2025, 2014.

Fulchin E., Joubard B., Granger D., Giffard B. (2018). Caractérisation et impact de la dégradation du fonctionnement biologique des sols viticoles, Etude de techniques de restauration compatibles avec la viticulture biologique, *Technique*. 169, 59-61.

Gis Sol. (2011). L'état des sols de France. Rapport.

Hannah L., R. Roehrdanz P., Makihiko I., Shepard A., Shaw R., Tabo G., Zhi L., Marquet P. & Hijmans R. (2013). Climate change, wine, and conservation. Proceedings of the National Academy of Sciences of the United States of America. Proceedings of the national academy of sciences, 110 (17), 6907–6912.

HCC - Haut Conseil pour le climat. (2022). Dépasser les constats, Mettre en œuvre les solutions.

Pellerin S., Bamière L. (scientific coordinators), Launay C., Martin R., Schiavo M., Angers D., Augusto L., Balesdent J., Basile-Doelsch I., Bellassen V., Cardinael R., Cécillon L., Ceschia E., Chenu C., Constantin J., Darroussin J., Delacote P., Delame N., Gastal F., Gilbert D., Graux A.-I., Guenet B., Houot S., Klumpp K., Letort E., Litrico I., Martin M., Menasseri S., Mézière D., Morvan T., Mosnier C., Roger-Estrade J., Saint-André L., Sierra J., Thérond O., Viaud V., Grateau R., Le Perchec S., Réchauchère O., 2020. Stocker du carbone dans les sols français, Quel potentiel au regard de l'objectif 4 pour 1000 et à quel coût ? Rapport scientifique de l'étude, INRA (France), 540 p.

Insee (2023). L'essentiel sur la Nouvelle-Aquitaine, Recensements de la population.

IPCC. (2022). Summary for Policymakers. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3–33, doi:10.1017/9781009325844.001.

Karimi B., Cahurel J.-Y., Gontier L., Charlier L., Chovelon M., Mahé H. et Ranjard L. (2020). Revue scientifique sur la qualité biologique des sols de vignes et l'impact des pratiques viticoles, Etude et Gestion des Sols, 27, 221- 239.

Karimi B., Masson V., Guilland C., Leroy E., Pellegrinelli S., Giboulot E., Maron P.-A. et Ranjard L. (2021). La biodiversité des sols est-elle impactée par l'apport de cuivre ou son accumulation dans les sols vignes ? Synthèse des connaissances scientifiques. *Etude et Gestion des Sols, 28*, 71-92.

Le Bissonnais Y., Thorette J., Bardet C., Daroussin J.. (2002). L'érosion hydrique des sols en France, IDEN et INRA, 2002.

Jeroen Meersmans, Manuel P Martin, Eva Lacarce, Sarah de Baets, Claudy Jolivet, Line Boulonne, Nicolas Saby, Sébastien Lehmann, Antonio Bispo, Dominique Arrouay (2012) A high resolution map of French soil organic carbon. *Agronomy for Sustainable Development*, 32 (4). 841-851.

OIV – Internation organisation of wine and vine. (2023). State of the world vine and wine sector in 2022. Report. 20p.

Ollat N., Touzard JM., van Leeuwen C. (2016). Climate change impacts and adaptations: new challenges for the wine industry. *Journal of Wine Economics, 11*, 139-149

Ollat N., Zito S., Richard Y., Aigrain P., Brugière F., Duchêne E., Garcia de Cortazar-Atauri I., Gautier J., Giraud-Héraud E., Hannin H., et al. (2021) La diversité des vignobles français face au changement climatique: simulations climatiques et prospective participative*. Climatologie, 18(3)*, 1-26. Doi : 10.1051/cli-mat/202118003.

Péres S. (2009). La résistance des espaces viticoles à l'extension urbaine. Le cas du vignoble de Bordeaux, *Revue d'Économie Régionale & Urbaine*, 1, 155-177

Pierdet M. (2020). Evolution spatiale et temporelle de la mobilité des contaminants organiques et inor- ganiques dans des sols viticoles contrastés. Ecotoxicologie. Université de Bordeaux. Français.

Sgubin G., Didier Swingedouw, Juliette Mignot, Gregory Alan Gambetta, Benjamin Bois, Harilaos Loukos, Thomas Noël, Philippe Pieri, Iñaki García de Cortázar-Atauri, Nathalie Ollat, Cornelis van Leeuwen. (2023). « Non-linear loss of suitable wine regions over Europe in response to increasing global warming ». *Global Change Biology*. 29, 808-826.

Smetanová A., Follain S., David M., Ciampalini R., Raclot D., Crabit A., Le Bissonnais Y. (2019). Landscaping compromises for land degradation neutrality: The case of soil erosion in a Mediterranean agricultural landscape. *Journal of Environmental Management*, *235*, 282-292, https://doi.org/10.1016/j.jenvman.2019.01.063.

van Leeuwen C., & Destrac-Irvine, A. (2017). Modified grape composition under climate change conditions requires adaptations in the vineyard. *OENO One, 51(2),* 147–154. https://doi.org/10.20870/oeno-one.2017.51.2.1647

van Leeuwen C. (2022). 9 - Terroir: The effect of the physical environment on vine growth, grape ripening, and wine sensory attributes, Woodhead Publishing, 2, 341-393. doi : 10.1016/B978-0-08-102067-8.00005-1.

Villain Milo. (2021). La transition agroécologique vécue par les viticulteurs de la cave coopérative de Buzet-sur-Baïse. 9éme Congrès de l’Association Française de Sociologie : “Changer?”, Lille, France.

Contact information (Email): flavien.poincot@acta.asso.fr

7 Annual Cropping North: East Denmark, Denmark

Jorge F. Miranda-Vélez

7.1 Regional Information

East Denmark is not an official political or administrative demarcation (Figure 7-1). Here, we define East Denmark as a physical region characterized by a predominance of loamy post-glacial moraine soils and a drier and warmer climate compared to other regions of the country.

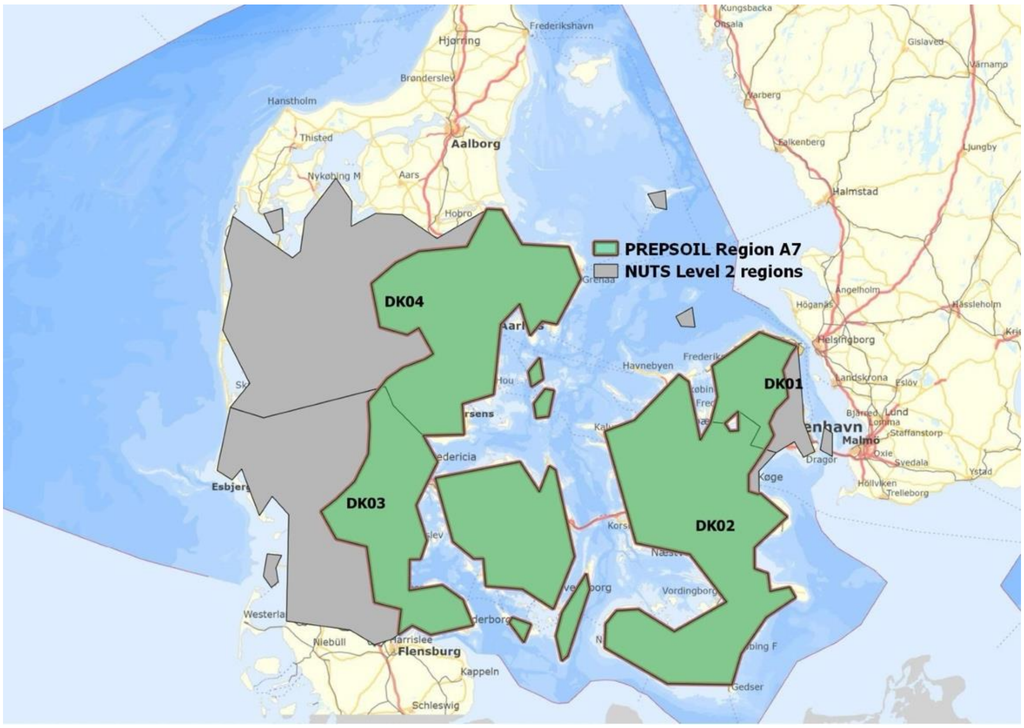


Figure 7-1: Map of the East Denmark region in Demark

The dominant land use in East Denmark is agriculture (approximately 59% of total land area in 2022), with a high proportion of cropping area devoted to annual cereals (55% in 2022). 2{, 2023 #1295}. Arable farms in East Denmark are averagely large (69 ha in 2022) and focus primarily on winter wheat, spring barley, and winter barley 2{, 2023 #1295}{, 2023 #1295}{, 2023 #1295}{, 2023 #1295}{, 2023 #1295}. Additionally, a majority of agricultural fields in Eastern Denmark are artificially drained due to the often poor natural drainage of the soil. Decades of intensive cropping have led to marine and riparian nutrient pollution from agriculture[4], high risks of soil compaction, soil erosion, and loss of soil organic carbon (SOC), negatively affecting fertility and soil health in general.Refer the following Table 7-1 for additional information.

Table 7-1:Regional information of annual cropping in East Denmark, Denmark

Dominant land use:	Arable agriculture (59% of the region's land area), primarily grains and cereals.
Secondary land use:	Agricultural, other types. Urban. Managed forest.
Climatic Zone:	Atlantic North, Continental.
Soil WRB classification:	Luvisols, Cambisols, Regosols.
Soil type:	Post-glacial moraine.
Dominant topsoil texture:	Loams, loamy sands and sandy loams.
Soil threat(s):	Soil organic carbon (SOC) loss, nutrient loss, compaction (topsoil and subsoil), water and tillage erosion, reduced water retention capacity, reduced soil fertility.
Representatives for regions:	Regions with similar soil and climate characteristics where annual cropping is also a dominant land use, e.g., Scania (Sweden), Southern Finland, Northern Germany, Northern France, Poland.

7.2 Stakeholder Interaction

From the desktop investigation, we identified three key groups of stakeholders involved with soil health in annual agriculture in East Denmark. The first group is the farmers and farm managers themselves, who apply different management practices and directly experience external drivers and pressures, as well as the state of the soil. The second group is farmer's advisors, who act as a key knowledge provider to the farmers and represent a very important point of contact with technological and policy-related drivers. The third group is the government's environmental protection, and food and agricultural agencies employees, who are in direct contact with the monitoring of environmental, economic and soil health-related indicators, as well as the human processes leading to agricultural and environmental regulations.

Given their different positions and perspectives, we decided to contact potential stakeholder participants among these three groups separately. Thus, the expectation was to extract the most valuable information from each group given their unique perspectives on soil health, without having their opinions or perceptions colored by interaction with the other two groups.

Eight farmers and farm managers from the islands of Zealand and Funen participated in a focus group/workshop in the spring of 2023, representing mostly well-established arable farm owners and managers in charge of large intensive operations, with the exception of two young farm employees from a small horticultural farm. Refer Figure 7-2 for the stakeholder groups. Even though we did not intentionally focus on any particular agricultural practice of principle, the majority of participants were interested in Conservation Agriculture and practiced some degree of minimal tillage, with the exception of the two horticultural farmers, who practiced organic agriculture. The focus group participants were asked to point out, from their own experience, what the main challenges for soil health in arable soil in East Denmark are, and which elements of the DPSIR framework they could identify as part of the causality behind these challenges.

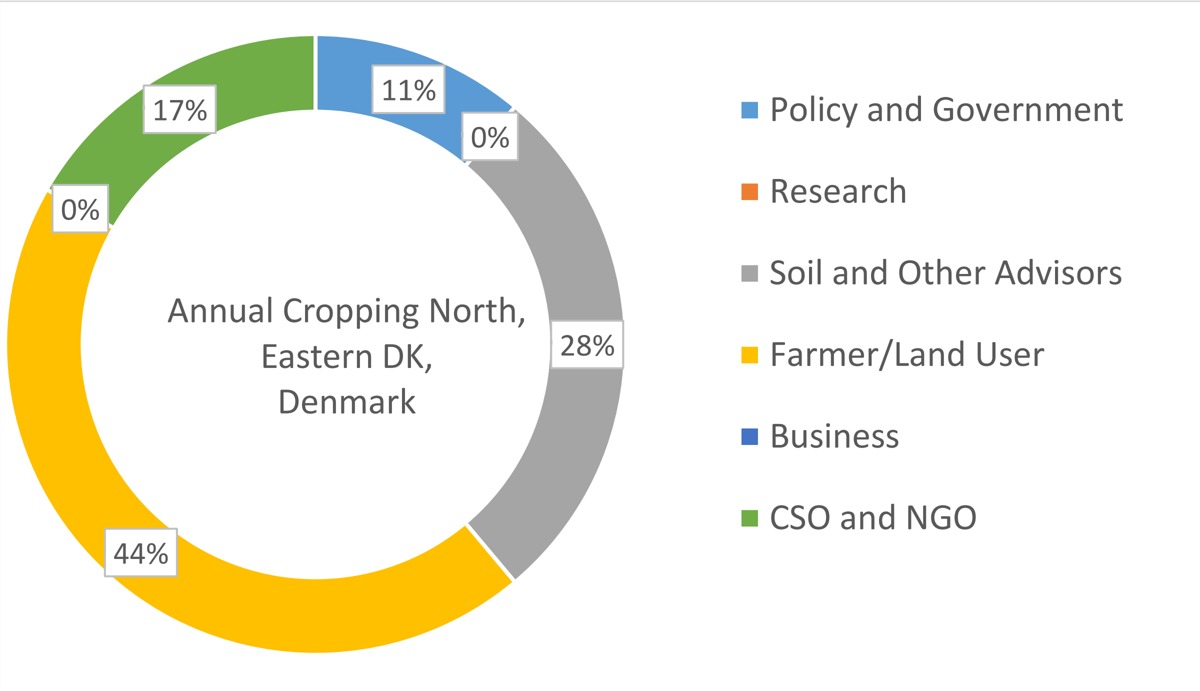


Figure 7-2: Stakeholder Interaction in East Denmark

7.3 Soil Needs Assessment

7.3.1 Drivers

Biophysical drivers: The three main biophysical drivers for soil health in East Denmark are:

- The intensification of agriculture after the 1950´s

- The proximity of vulnerable aquatic ecosystems
- Anthropogenic climate change.

A trend of farm consolidation took place throughout the second half of the 20th century, where the number of farms nationwide fell from approximately 200,000 to 37,000. During that time, the national average farm size grew from 17 ha to 72 ha[8], and production shifted focus to high-yield cereals. No point in Denmark is further than 52 km from the coast[9]. This, combined with a relatively shallow groundwater table[10], widespread artificial field drainage[3] and intensive arable farming, has made nutrient pollution of aquatic environments the main environmental issue in Denmark for decades[4].

Finally, anthropogenic climate change in Denmark, as in Northern Europe in general, is expected to result in wetter and milder winters, fewer full days of frost, and longer growing seasons for most crops[11-13]. This is the main future biophysical driver in the region, potentially increasing the productivity of existing cash crops, allowing for cultivation of new crops (e.g., grain legumes and perennial grains), but also greatly increasing the risks of N leaching during winter and the appearance of new pests and weeds previously held back by winter frost.

Socioeconomic drivers: Generally, the principal drivers for soil health in East Denmark are:

- The entrenchment of conventional practices
- Strict regulations for reducing nutrient pollution

Around 87% of all arable farms in Denmark are farmer-owned[14]. This interacts poorly with a generally old population of farmers (avg. 53.6 years), resulting in the entrenchment of conventional practices. Moreover, farmer's education programs and family traditions do not typically ascribe much importance to practices that deviate from the intensive, specialized, and mechanized paradigm[15,16], and advisory services are often reticent to suggest changes from conventional practices to their farmers. Furthermore, according to participating farmers, pioneers in certain practices are often ahead of established science and policy and thus often conflict with regulations or mainstream advice. This creates the feeling that pioneer farmers are systematically "punished", even though their early efforts are vital for the development and popularization of new practices.

The most notable regulation-related drivers in East Denmark are regulations aimed at reducing the environmental impact of agriculture on aquatic ecosystems. These include nitrogen fertilizer application quotas, strict rules for storage and application of animal slurry, and compulsory use of cover crops, among others[1,17]. Overall, these policies have resulted in a 50% reduction in the average fertilizer-N input in Danish farms in the period 1990-2010[4], and have been effective in reducing N leaching[1], but have had economic and methodological consequences for farmers. In particular, N-application quotas have meant an increased focus on crops that give the highest economic return and on the content of available N in fertilizers[4].

Furthermore, two new drivers are likely to have an increased effect on the region in the future:

- Recent popularization of regenerative practices (e.g., Organic Agriculture, Conservation Agriculture)
- Technological developments in precision and digital tools

Organic crop production is moderately widespread in Denmark (11.7% of all agricultural areas and 7% of cereal grain production[18]) and generally considered environmentally friendly, and protective, and/or regenerative of soil health[19]. Practices involving minimal or zero tillage operations (e.g., conservation tillage, no-till, conservation agriculture[20]) have also gained popularity in recent years, increasing from 10% of all potentially tilled agricultural and horticultural areas in Denmark in 2011, to 26% in 2022[2]. Precision agriculture, digital farming, use of robots, and remote sensing for supporting management decisions are also among the tools and strategies that have gained recent popularity in East Denmark and that show potential for improving soil health and preventing nutrient mismanagement[21,22].

7.3.2 Pressures

Both positive and negative pressures were identified in arable farming in East Denmark, principally related to the different conventional and alternative practices applied by farmers:

- Excessive tillage and heavy machine traffic (negative)
- Minimal or zero tillage, including as part of Conservation Agriculture (positive)
- Excessive use of mineral and carbon-poor fertilizers (negative)
- Organic management and principles (positive)
- Periods of grass cultivation, including grass seed production (positive)

Farmers and advisors principally interested in Conservation Agriculture pointed out tillage as the main negative pressure affecting soil health in East Denmark. This is to some extent supported by scientific and agronomical research, which shows that frequent tillage adds a significant risk of erosion by negatively affecting soil structural properties[23]. Furthermore, traffic with heavy field machinery (wheel load > 3 tons) has a high chance of causing compaction in the subsoil[24], even though much of this traffic is meant for loosening the topsoil through tillage.

Agricultural practices that incorporate minimal or zero tillage, on the other hand, represent a positive pressure on the future of soil health in East Denmark[25]. Minimal tillage practices have shown potential for helping ameliorate subsoil compaction in the medium to long term in loamy soils when combined with increased plant residue retention and catch crops[26,27]. Similarly, it has been documented that in loamy and clayey soils in Scandinavia and Finland, minimal tillage can greatly reduce phosphorous losses due to erosion[28]. In the case of Conservation Agriculture, both increased SOC storage and reduced N leaching can be observed, although they are primarily related to the use of diversified crop rotations, cover crops and in-field retention of straw and crop residues rather than tillage intensity itself[25]. Here, however, the increased on-field retention of plant residues may increase dissolved phosphorus emissions to drains and surface water bodies[25].

Overall, research literature, farmers, and farmer's advisors agree that excessive use of mineral fertilizers over organic fertilizers, especially C-rich solid manures, represents a negative pressure leading to C-depleted soils, poorer structure, and poor soil health in general.[29]. When asked about negative pressures, organic agriculture advisors highlighted that the use of pig slurry over solid manures as fertilizer also leads to losses in SOC and poorer soil health due to their relatively poor C content. These concerns are supported by nation-wide soil carbon data collected between 1986 and 2009, which show that cattle manure promotes a greater accumulation of SOC in agricultural soil compared to the use of mineral fertilizers, while pig slurry does not[30].

Organic agricultural practices overall constitute a positive pressure that has become widespread in Denmark over the last two decades, although the area dedicated to organic grain production has seen a slight decline since 2019[18]. Here, alongside the exclusive use of organic fertilizers, organic agriculture advisors expressed that diverse and well-planned crop rotations can potentially ameliorate SOC and nutrient losses caused by the use of carbon-poor fertilizers and tillage.

Finally, both Conservation Agriculture and organic farming advisors mentioned seed grass production over 2-5 years as a positive pressure for soil health, as it promotes the formation of natural structure in the soil and the accumulation of SOC. This practice, although economically important and currently expanding, is unfortunately not dominant in terms of total area, and less than 10% of all arable land in East Denmark involves the production of grass seeds[2].

7.3.3 State

A number of negative soil health indicators can be recognized in East Denmark arable soils:

- Low SOC content
- Nutrient depletion

- Soil compaction
- Reduced water holding capacity
- Erosion risks from water and tillage.

These issues are highly interconnected, as particulate matter loss from soil erosion degrades the organic carbon and nutrient content in the soil, making it less fertile and more susceptible to compaction[31]. Meanwhile, compaction, particularly subsoil compaction, and low SOC content hinder water infiltration and storage, thus increasing runoff and the risk for water erosion as well as exacerbating the effects of drought[6]. Similarly, compacted soils typically require more frequent and/or more aggressive tillage, which greatly promotes tillage erosion and thus further SOC and P loss. Finally, poor soil fertility incentivizes farmers to favor N-rich fast-acting fertilizers rather than C-rich manures, contributing to SOC and P and K depletion.

Sixty-nine percent of all soil organic C in Denmark can be found in the top 1 m of agricultural soils, and 40% in the top 0.2 m alone[32]. This makes losses in SOC from agricultural soil particularly important for Denmark's overall carbon stocks. Danish loamy soils under agricultural land use, the dominant soil type in East Denmark, showed a trend of SOC depletion (-1.24 ton C ha^{-1} y^{-1}) in the upper 1 m between 1986 and 2009[30]. More recent analysis of soil carbon stocks in Denmark show further small SOC losses (<1 ton C ha-1) in the upper 0.25 m and moderate increases (1.9-3.2 ton C ha^{-1}) in the subsoil between 0.25 and 0.5 m depth of loamy soils between 2009 and 2019[33]. Overall, SOC stocks are lower in loamy soils than in sandy soils and tend to decrease in the topsoil while increasing in the subsoil[33].

A 2019 report by the Danish Centre for Food and Agriculture[34] mentions that by the 1980's, 39% of all Danish mineral soils in agricultural use had critically high densities, i.e., were compacted. They further reason that since that data was collected, continued tillage and machine traffic will have only exacerbated the compaction problem in many, if not most, Danish agricultural soils[34]. More recent analyses estimate that 18% of all agricultural land in Denmark is highly vulnerable to compaction[35]. Importantly, these results are not regionalized within Denmark, but given the prevalence of arable farming and loamy soils, it is likely these figures are worse in East Denmark.

The most significant erosion risks in East Denmark's loamy soils come from water and tillage[23]. Recent modeling at a very fine spatial resolution (10 m x 10 m grid) found that about 12% of all agricultural land in Denmark is in risk of moderate water erosion rates (1-2.5 ton ha^{-1} y^{-1}), while 6.1% is in risk of unsustainably high water erosion rates (>2.5 ton ha^{-1} y^{-1})[36]. Earlier modeling in Denmark has shown a concentration of areas with high risk of sheet and rill erosion in the sloping loamy soils of eastern Jutland and the archipelago[37] (Fig. 2). Meanwhile, individual studies from Denmark have found moderate to high risks of water erosion rates in soils under annual crops (e.g., 0.45-2.69 ton $ha^{-1}y^{-1}$ in spring grain tilled in autumn and 1.17-

12.79 ton ha^{-1} y^{-1} in winter wheat drilled parallel to the local slope)[5]. Additionally, tillage has been found to account for an added erosion risk of approximately 6.0 ton ha^{-1} y^{-1} [5].

7.3.4 Impacts

The most relevant Ecosystem Services directly affected by poor soil health in East Denmark can be summarized in four themes:

- Provision of cultivated plants (for nutrition, materials, and energy)
- General provision of surface and groundwater
- Pest and disease control (in crops)
- The chemical composition of the atmosphere (with focus on carbon sequestration and GHG emissions)

Soil compaction impacts the provision of groundwater and cultivated plants by reducing the water holding capacity of the soil, which in turn increases the risk of groundwater contamination with nutrients and agrochemicals as well as making crops more susceptible to water stress and drought[23,34].

Erosion and SOC depletion directly impact the provisioning of cultivated plants as they deplete the nutrient content of the soil, primarily P and N, while erosion contributes itself to SOC depletion via the loss of fine soil particles enriched with SOC[23].

There is a concern amongst both farmers and advisors that milder and wetter winters in Denmark caused by climate change may lead to more frequent and severe incidences of pests and crop diseases, impacting the pest and disease control service of a healthy soil. This impact, according to farmers' advisors, is potentially exacerbated by inadequate and/or poorly diverse crop rotations.

Finally, both compaction and SOC losses impact the chemical composition of the atmosphere. Soil compaction increases the risk of the release of nitrous oxide (N_2O)[38] and methane (CH_4)[34], two potent greenhouse gases, into the atmosphere. Meanwhile, SOC losses in agricultural soil imply a reduction in the most important terrestrial carbon sink in East Denmark and an imbalance in the soil-atmosphere carbon equilibrium.

From the perspective of farmers, these impacts translate into reduced yield stability, i.e., greater variability in agricultural outputs over time and decreased resilience to environmental changes such as weather extremes, pests, and crop diseases. Yield instability, in turn, results in increased expenses as farm managers invest more in agrochemical inputs, professional advice, and/or field operations in order to counter the effects of poor soil health.

From a policy point of view, these impacts hinder the accomplishment of national water quality and GHG emission targets. Here, participating employees of the Danish Agricultural Agency expressed that reducing N pollution in freshwater and coastal environments remains a priority for national authorities and that, in spite of past improvements to surface water quality and N emissions from agriculture, further reducing the latter remains a policy challenge.

7.3.5 Response

East Denmark and Denmark as a whole find themselves in a period of agricultural transition. As such, traditional responses to the impacts of poor soil health are beginning to give ground to a new set of adaptations, but they are still very much present. Thus, the main Responses to the Drivers, Pressures and State identified in East Denmark are:

- Increase in farm sizes and further intensify practices to take advantage of economies of scale and make up for yield losses and instability.
- Focus new technological or methodological investments towards reversing, ameliorating, or coping with poor soil health without fully downscaling or de-intensifying production (e.g., adopting Conservation or Precision agriculture).
- Faster change on large corporate farms than on smaller farmer-owned farms.
- Faster change in younger farmers than in older farmers
- Increased policy focus on soil health and climate goals will bring new regulations and stimuli, but alignment with farmers' interests is not guaranteed.
- Novel research approaches investigating the effectiveness and applicability of new management ideas and technologies with the farmers at the center (e.g., Soil Mission, Living Labs)

7.4 Conclusions

Research and innovation in East Denmark should prioritize the scientific and practical validation of emerging agricultural practices (Regenerative practices, Conservation Agriculture, Precision Agriculture, etc.) that have potential for improving soil health in intensive cropping systems. Importantly, policymakers, advisory services, and farmer's schools should be involved in investigating new practices along with researchers and farmers. This involvement is key to increasing the adaptability of regulations in the region as well as promoting the teaching and communication of innovative practices based on sound and meticulous scientific knowledge. Without multilateral involvement, it is unlikely that Denmark's strict regulations will evolve at the necessary pace or in the optimal direction, while the farmers' appetite for innovation will be stymied by poor access to trustworthy knowledge and expertise.

Given both the history and the present socio-economic conditions in the region, de-intensification and down-scaling of cropping agriculture in East Denmark are likely not realistic solutions. Rather, priority should be given to researching strategies that allow farmers in this and similar regions to reduce operation costs in the short term while improving soil health in the medium and long term, all while maintaining farm productivity.

7.5 References

Kronvang, B. *et al.* Effects of policy measures implemented in Denmark on nitrogen pollution of the aquatic environment. *Environmental Science & Policy* **11**, 144-152 (2008). https://doi.org:10.1016/j.envsci.2007.10.007

AFG5: Cultivated area by region, unit and crop, <www.statbank.dk/AFG5> (2023).

Møller, A. B., Beucher, A., Iversen, B. V. & Greve, M. H. Predicting artificially drained areas by means of a selective model ensemble. *Geoderma* **320**, 30-42 (2018). https://doi.org:10.1016/j.geoderma.2018.01.018

Dalgaard, T. *et al.* Policies for agricultural nitrogen management-trends, challenges and prospects for improved efficiency in Denmark. *Environmental Research Letters* **9** (2014). https://doi.org:10.1088/1748-9326/9/11/115002 , file = :C\:/Users/au630500/Dropbox/PhD Foulum/Lit/N Leaching/Dalgaard_2014.pdf:pdf

Veihe, A., Hasholt, B. & Schiøtz, I. G. Soil erosion in Denmark: processes and politics. *Environmental Science & Policy* **6**, 37-50 (2003). https://doi.org:10.1016/s1462-9011(02)00123-5

Soil threats in Europe. (EU Joint Research Centre, Luxembourg, 2016).

Taghizadeh-Toosi, A. *et al.* Deliverable D2.6 Set of reports on State of knowledge in agricultural soil management. (2021).

Pedersen, H. B. & Møllenberg, S. 59 (Danmarks Statistik, Denmark, 2017). *Ferie i Danmark: 5 fredede kyster du skal besøge*, <https://www.dn.dk/nyheder/ferie-i-danmark-5-fredede-kyster-du-skal-besoge/

Duque, C., Nilsson, B. & Engesgaard, P. Groundwater–surface water interaction in Denmark. *WIREs Water* (2023). https://doi.org:10.1002/wat2.1664

Peltonen-Sainio, P. in *BUILDING RESILIENCE FOR ADAPTATION TO CLIMATE CHANGE IN THE AGRICULTURE SECTOR.* (eds Alexandre Meybeck *et al.*) 183-216 (Food and Agriculture Organization of the United Nations (FAO)).

Olesen, J. E. *et al.* Impacts and adaptation of European crop production systems to climate change. *European Journal of Agronomy* **34**, 96-112 (2011). https://doi.org:https://doi.org/10.1016/j.eja.2010.11.003

Andersen, M. N. *et al.* Vidensyntese om klimatilpasning og landbrug. 123 (Aarhus Universitet, 2022).

Hansen, E. M. Ø., Egmose, J., Lund, S. & Hauggaard-Nielsen, H. The role of experience exchange groups in farmers' practice transitions: the case of reduced tillage in Danish conventional farming. *Agroecology and Sustainable Food Systems* **44**, 1012-1032 (2020). https://doi.org:10.1080/21683565.2020.1726550

Aare, A. K., Egmose, J., Lund, S. & Hauggaard-Nielsen, H. Opportunities and barriers in diversified farming and the use of agroecological principles in the Global North – The experiences of Danish biodynamic farmers. *Agroecology and Sustainable Food Systems* **45**, 390-416 (2021). https://doi.org:10.1080/21683565.2020.1822980

Aare, A. K., Lund, S. & Hauggaard-Nielsen, H. Exploring transitions towards sustainable farming practices through participatory research – The case of Danish farmers' use of species mixtures. *Agricultural Systems* **189**, 103053 (2021). https://doi.org:10.1016/j.agsy.2021.103053

N/A. *Implementation of the Nitrates directive in Denmark*, <https://eng.mst.dk/trade/agriculture/nitrates-directive/implementation-in-denmark/>

(N/A).Statistik over økologiske jordbrugsbedrifter 2022. 57 (Lanbrugsstyrelsen, 2022)

Hansen, B., Alroe, H. F. & Kristensen, E. S. Approaches to assess the environmental impact of organic farming with particular regard to Denmark. *Agr Ecosyst Environ* **83**, 11-26 (2001). https://doi.org:10.1016/S0167-8809(00)00257-

Conservation Agriculture, <https://frdk.dk/category/conservationagriculture/> (2023).

Pedersen, S. M., Fountas, S., Blackmore, B. S., Gylling, M. & Pedersen, J. L. Adoption and perspectives of precision farming in Denmark. *Acta Agriculturae Scandinavica, Section B - Soil & Plant Science* **54**, 2-8 (2004). https://doi.org:10.1080/09064710310019757

Fountas, S., Gemtos, T. A. & Blackmore, S. in *Soil Engineering* (eds Athanasios P. Dedousis & Thomas Bartzanas) 69-80 (Springer Berlin Heidelberg, 2010).

Schjønning, P., Heckrath, G. & Christensen, B. T. Threats to soil quality in Denmark - A review of existing knowledge in the context of the EU soil thematic strategy. 121 (Faculty of Agricultural Sciences, Aarhus University, Tjele, Denmark, 2009).

Schjønning, P., Lamandé, M., Crétin, V. & Nielsen, J. A. Upper subsoil pore characteristics and functions as affected by field traffic and freeze–thaw and dry–wet treatments. *Soil Research* **55** (2017). https://doi.org:10.1071/sr16149

Munkholm, L. J. *et al.* VIDENSYNTESE OM CONSERVATION AGRICULTURE. Report No. 177, (Aarhus Univesrity, 2020).

Munkholm, L. J., Heck, R. J. & Deen, B. Long-term rotation and tillage effects on soil structure and crop yield. *Soil and Tillage Research* **127**, 85-91 (2013). https://doi.org:10.1016/j.still.2012.02.007

Blanco-Canqui, H. & Ruis, S. J. No-tillage and soil physical environment. *Geoderma* **326**, 164-200 (2018). https://doi.org:10.1016/j.geoderma.2018.03.011

Ulén, B. *et al.* Soil tillage methods to control phosphorus loss and potential side-effects: a Scandinavian review. *Soil Use and Management* **26**, 94-107 (2010). https://doi.org:10.1111/j.1475-2743.2010.00266.x

Chen, Y., Camps-Arbestain, M., Shen, Q., Singh, B. & Cayuela, M. L. The long-term role of organic amendments in building soil nutrient fertility: a meta-analysis and review. *Nutrient Cycling in Agroecosystems* **111**, 103-125 (2018). https://doi.org:10.1007/s10705-017-9903-5

Taghizadeh-Toosi, A. *et al.* Changes in carbon stocks of Danish agricultural mineral soils between 1986 and 2009. *European Journal of Soil Science* **65**, 730-740 (2014). https://doi.org:10.1111/ejss.12169

Arthur, E., Schjønning, P., Moldrup, P. & de Jonge, L. W. Soil resistance and resilience to mechanical stresses for three differently managed sandy loam soils. *Geoderma* **173-174**, 50-60 (2012). https://doi.org:10.1016/j.geoderma.2012.01.007

Krogh, L. *et al.* Preliminary estimates of contemporary soil organic carbon stocks in Denmark using multiple datasets and four scaling-up methods. *Agriculture, Ecosystems & Environment* **96**, 19-28 (2003). https://doi.org:10.1016/s0167-8809(03)00016-1

Harbo, L. S., Olesen, J. E., Lemming, C., Christensen, B. T. & Elsgaard, L. Limitations of farm management data in analyses of decadal changes in <scp>SOC</scp> stocks in the Danish soil-monitoring network. *European Journal of Soil Science* **74** (2023). https://doi.org:10.1111/ejss.13379

SCHJØNNING, P., LAMANDÉ, M. & THORSØE, M. H. SOIL COMPACTION – DRIVERS, PRESSURES, STATE, IMPACTS AND RESPONSES. (DCA - Danish Centre for Food and Agriculture, Tjele, Denmark, 2019).

Greve, M. *et al.* Soil mapping and priorities in Denmark. *Geoderma Regional* **29** (2022). https://doi.org:10.1016/j.geodrs.2022.e00527

Onnen, N. *et al.* Distributed water erosion modelling at fine spatial resolution across Denmark. *Geomorphology* **342**, 150-162 (2019). https://doi.org:10.1016/j.geomorph.2019.06.011

Olsen, P. & Kristensen, P. R. *Nutrient Cycling in Agroecosystems* **50**, 307-311 (1998). https://doi.org:10.1023/a:1009769101746

Pulido-Moncada, M., Petersen, S. O. & Munkholm, L. J. Soil compaction raises nitrous oxide emissions in managed agroecosystems. A review. *Agronomy for Sustainable Development* **42** (2022). https://doi.org:10.1007/s13593-022-00773-9

Contact information (Email): jorge_mv@agro.au.dk

8 Large Scale Annual Cropping: Emilia-Romagna, Italy

Pietro Bazzocchi (pietro.bazzocchi@resoilfoundation.org), Margherita Caggiano (Margherita Caggiano; margherita.Caggiano @resoil foundation.org)

8.1 Regional Information

The Po Valley region is located within the administrative Italian region "Emilia-Romagna"; specifically, it includes its plains, where there is the highest concentration of farms and the most fertile arable land in Italy. The extension of the area is 1.181.650 ha and includes the provinces of Piacenza, Parma, Reggio-Emilia, Modena, Ferrara, Bologna, Ravenna, Forlì-Cesena, and Rimini.

The region (the regional map was taken from Tarocco, Aprea, et al. (2021)) is characterized by a temperate subcontinental climate with hot and humid summers and cold, severe winters. The region's soils are mainly alluvial, with altitudes ranging from 0 to 150 meters. In the provinces of Ferrara and Ravenna, depression areas have been created through massive reclaim operations on swamps, resulting in economic and social improvements. The soils are medium to fine, with high fractions of alterable minerals and carbonates. However, their properties show high variability due to past hydraulic reclamation works and current agricultural management practices. Areas made available through drainage are at greater risk of instability (Table 8-1:Regional information of the Po valley, Italy). Agriculture is the prevailing land use in the region, with intensive specialized crops in the eastern plain and extensive herbaceous crops in the central and western plains. The natural vegetation, both managed and unmanaged, covers small areas not suitable for agricultural use, mainly in the Po Delta Park. Climate change has led to an imbalance in rainfall distribution and the intensification of extreme events, increasing the region's risk of droughts and floods. In the last few years, over a thousand landslides have been registered; 300 have caused significant damage to 54 municipalities. Due to the high population density in the region, the main threats to soils are:

- consumption and sealing, which show no sign of stabilization or reduction, driven by a strong demand from the logistics sector;
- loss of organic matter resulting in the reduction of soil fertility due to past agricultural practices involving clod inversion and deep aeration of the land (intensive tillage) and lack of availability of manure, caused by the industrialization of the agricultural business.

Table 8-1:Regional information of the Po valley, Italy

Dominant land use:	Agriculture: croplands
Secondary land use:	Urban/industrial

Climatic Zone:	Temperate Subcontinental
Soil WRB classification:	Cambisols
Soil type:	Altogether, 210 soil types have been identified in the area[a]. These soils' origins are alluvial, and the altitude range varies roughly between 0 and 150m on the sea level.
Dominant topsoil texture:	Variable texture, predominantly medium to fine, with a high fraction of alterable minerals and carbonates.
Soil threat(s):	Soil consumption and sealing; soil organic matter loss; moderate- high risk of drought; moderate-high risk of flood; moderate risk of soil erosion; high risk of soil pollution; low risk of soil salinity; low- moderate risk of functional soil biodiversity deterioration.

8.2 Stakeholder Interaction

To better engage the stakeholders and assess the soil needs in the region, a workshop[24] had been held on the 4 May 2023 in Rimini with the title: "LET'S PREPARE THE SOIL FOR THE FUTURE: THE EUROPEAN PROJECTS PREPSOIL AND EXCALIBUR AND THE DEMONSTRATION REGION OF THE PO VALLEY". The workshop was organized at MACFRUT, one of the most important Italian fair show for the agricultural and fruticulture sector. The presence of growers, technicians, institutional and scientific stakeholders in Rimini for the event made this an ideal location for meeting. The event had been carried out and organized together with another one dedicated to the European project EXCALIBUR[25], aiming to engage a higher number of stakeholders. The idea behind this meeting was to ask to the main categories of stakeholders to present their views on which are considered the main problems/barriers for the soil management in the selected region, and which can be possible solutions to them. Refer the below Figure 8-1 for the different stakeholder groups interacted in the workshops.

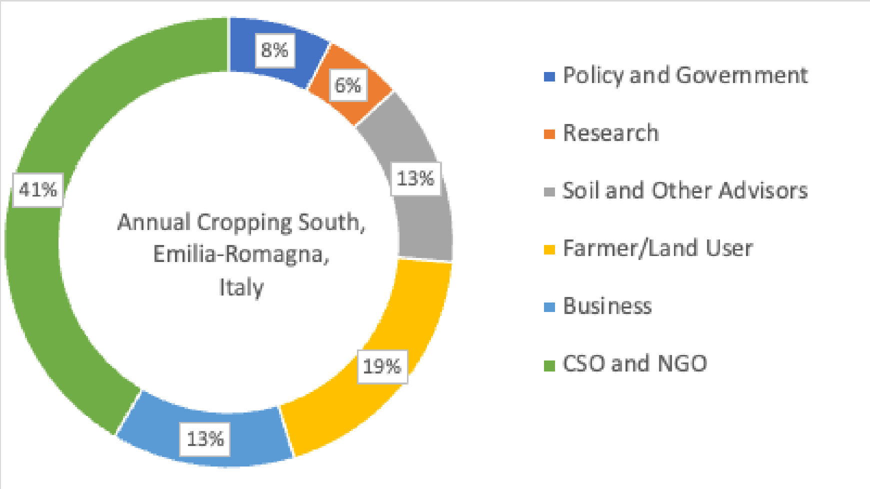


Figure 8-1:Stakeholder interaction in Emilia-Romagna, Italy

8.3 Soil Needs Assessment

8.3.1 Drivers

Biophysical Drivers: Climate change is a significant driver in the region, affecting water and temperature regimes. During hotter times, resource shortages occur, leading to increased agricultural demand. Temperature fluctuations directly affect plant growth and farm operation management. Specifically, extreme weather events are increasingly taking place.

Extreme precipitation: Simultaneously, the total precipitation in 2022 was 676.6 mm, which is the fifth-lowest amount since 1961. Rainfall is becoming more concentrated over shorter periods, resulting in longer droughts and higher flooding hazards. At the same time, high demands for water resources were placed on the agriculture sector. The most recent instance of this were the floods in May 2023, which resulted in flooding in numerous towns, landslides, and the deposition of mud and loam on soils. Cumulative precipitation during this event nearly quadrupled that in 2022. The effects on fertility have not yet been identified.

Temperatures: The medium annual temperature rose by 1.2°C until 2022; in comparison to 1961–1990, the summer temperature has risen by 4.7°C, while the minimum temperature has increased by 2°C (average). Snowfalls have also changed, which leads to water quality and quantity changes. From 1961 to 2020, as a result, fewer snowfalls occurred, which had an impact on Emilia-Romagna, a region with a high water demand because of its significant agricultural presence. Improving water usage efficiency and reviewing big reservoirs as ways to adapt to climate change.

Socio-economic drivers: Farm abandonment: Over the past 50 years, the management of small landowners has gradually decreased in the Italian agricultural sector (63.8% decrease since 1982). Contextually, it had taken the direction of a sectionalization of the business and the agricultural activities in favor of the industrial production system and land management. As a result, economic and agricultural activities have become more segmented. Since 2010, the Emilia-Romagna region has seen a 26.8% decrease in the number of operational farms. Employment in the agricultural sector has risen in the years during and after the pandemic in comparison to the reference years 2018–19. The suspected cause is the influx of family businesses, and the trend of farm abandonment is stabilizing.

Policy: The Common Agricultural Policy strongly influences farmers' decision-making.The soil protection measures for regional development include five Italian eco-schemes. These are aimed at increasing cover crops and improved grazing practices on tree crops and fodder production systems with crop rotations (Ministero dell’Agricoltura della Sovranità Alimentare e delle Foreste, 2023) as well as the adoption of sod seeding and no tillage operations. The strategic plan for CAP 23–27 of Emilia-Romagna includes an action-based payment per hectare of arable land for the adoption of sod seeding practices and no tillage operations. Additionally, land management has seen extensive agricultural systems developed over the past 50 years, with the presence of buffer zones and natural areas potentially increasing due to the introduction of the carbon farming strategy. Mechanization in agriculture has also evolved, with 22.2% of farms in Emilia-Romagna investing in innovation in 2018–20, with 55.6% of these investments focusing on mechanization. A further socio-economic driver could be identified in increased investments in innovative technologies (22,2 %) of farms declared to invest in these practices.

Expansion of cities: The building activity in the Emilia-Romagna region is considered a driver of soil loss, as 19 ha per day are converted in the period 2020–21.

8.3.2 Pressures

Building activity: The soil loss in the region is primarily due to the construction of new infrastructure, buildings, houses, and commercial settlements, leading to soil sealing.

Agricultural and animal production: The shift from a small landowner's agriculture activity to an industrial and segmented type resulted in a reduction in the animal production sector, and its relocation to the northern-west part of the region has affected the availability of manure, soil nutrition, element equilibrium, and soil organic matter content. This has decreased significantly in cropland and fruticulture areas, while in the zone where animal raising is concentrated, animal waste is a by-product that needs to be disposed of. The misalignment of the livestock sector and crops has led to an over-availability of manure and animal waste on regional soils, causing farmers to compensate with other fertilizers.

Landscape element renewal: In the past 50 years, land management has seen an important development of intensive agricultural systems at the expense of hedgerows, buffer strips, and woods that were once typical land uses present on the territory (driven by CAP rules during those years). The presence in the region of these buffer zones and natural areas previously mentioned could see an increase due to the evolution of the Carbon Farming strategy.

Mechanization, technologies, and land management: The agricultural management adopted specific machinery, requiring a different organization of the crops and land preparation. The increase in mechanization is a trend that follows the transition from conventional agriculture, which included lots of in-depth tillage and plowing, to more conservation systems characterized by no-till approaches. However, it is not yet possible to replace fully conventional practices with conservative ones; for example, on the tomato crop, some tillage operations that bring air into the soil are still required for the health of the plants' roots. In this case, the tillage depth has been reduced in favor of operations that are more superficial. Climate change also had an impact on this; in fact, the drought causes the soil to be tougher, increasing therefore the energy required to work the soil and increasing the cost of tillage. Superficial tillage is now more sustainable, both economically and environmentally.The availability of mapping tools for soil and crops that allow the practice of variable-rate fertilization as well as precision farming technologies, e.g., drone use and mapping tools.

8.3.3 State

Soil health indicators describe the current state of soils in the Po Valley. Emilia-Romagna has selected the sampling sites for granulometry, pH in water, organic carbon, and total limestone available for the first 100 cm of depth. The significant parameters that have been analyzed are bulk density and permeability (Ksat). From these data sets, the Ksat map of plane soils and the ecosystem services map have been produced (Tarocco, Calzolari, et al., 2021).

Soil organic matter content is a key parameter linked to the soil functionality and productivity. As previously reported, the soil organic matter (SOM) is decreasing and its content is already low (0.98–2.26%). Due to the decline in SOM, soil management practices on the field have switched toward more conservative ones (minimum or no-till). Since 2011, the region has started monitoring soil organic carbon content, with a soil map at 1:50.000 scale available. The mean organic carbon content in the first 30 cm of agricultural soils varies between 0.98% under permanent crops and 2.266% under permanent croplands. This distribution reflects different management and agricultural practices in the region, with some districts having fodder crops for zootechny while others have intensive croplands and fruticulture.

The SOM decrease has influenced the nutrient equilibrium: in some areas there is an excess of nitrogen due to excessive artificial fertilizations or to high stocking rates of livestock, making the entire area of Ferrara and the part of the plains of Piacenza, Parma, Reggio-Emilia, and Modena even more susceptible to nitrate pollution in the groundwater (Arpae & Regione Emilia-Romagna, 2023) The net soil consumption of +658 ha significantly increases the amount of land unable to provide ecosystem services due to the impermeable layers set by urbanization operations. Impacts are particularly evident on the hydrological cycle, the water levels and outflow in rivers and channels, depurators, and sewerages, observing derivative effects on certain nutrient cycles such as N and P (Viaroli et al., 2018). On the water quality and availability topic, due to the wideness and interconnection of the Po river basin, the policies actuated in Lombardia and Piemonte have effects on the water quality of Emilia-Romagna.

Socioeconomic situation: Between 1960 and 1990, agricultural land use decreased primarily at the expense of meadows and pastures, due to progressive abandonment of mountain areas and rapid urbanization; traditional crops, such as grain, were replaced by more hydro-exigent ones (corn, rice), which require higher fertilizer input. Simultaneously, pig breeding increased from 1.2 million to nearly 5 million at the expense of cattle. This shift coincided with the abandonment of the traditional conduction system in favor of an industrial one characterized by larger zootechnological farms (Viaroli et al., 2018). Hence, livestock manure had become a waste to dispose of rather than useful for fertilization, with problematic issues of soil (and water) contamination.

Urban expansion: Soil sealing has gradually increased, nearly doubling from 1976 to 2008 (100.600 ha changed from agricultural to urban/industrial land use) (Regione Emilia-Romagna, 2015).

Photovoltaic expansion: In the last decade, the sector of photovoltaic installations in rural areas (covering the soil) has grown. This trend has now ceased, and the focus has shifted to floating photovoltaic systems (Regione Emilia-Romagna, 2015). In terms of soil consumption, it has not ceased: over the last decade, the logistics sector has consumed a significant amount of soil for new infrastructure. The impact of the soil is significant, as sealed soils provide virtually no function or ecosystem services to the biosphere or anthroposphere.

8.3.4 Impacts

Overall, the quality of the soil's structure is lowering, water retention has decreased, and the mineralization of nutrients is faster. The described pressures have impacts on management: production costs have increased (e.g., for fertilization and tillage operations). The actual state of the soils in the region already has a significant impact on water retention and availability, soil stability, and structure. The impact on these ecosystem services is primarily on ground stability, which is frequently jeopardized as extreme weather events cause flooding and landslides, which are hazardous to people's safety (Viaroli et al., 2018), infrastructure stability, and relevant services such as transportation (both of goods and people). Land instability affects agricultural soils in the same way, causing psychological distress for farmers about their livelihoods.

Pandemic: The pandemic showed that the actual business and economic model are not sustainable and cannot last due to the unbalanced use of natural resources. The psychological and cultural impacts of the COVID-19 pandemic probably had a relevant impact on rural development: an observable growth in infrastructure and service capacity building in rural centers. In the aftermath of the pandemic, especially younger people returned to the countryside and found employment in the sector (+13,1% dependent workers, +14,7% independents). The milk production industry contributed the most to the regional agricultural sector (28.5% of the total) (Fanfani & Boccaletti, 2020).

Farm resilience: The loss of resilience of the soil toward disturbance (weather, agronomical practices) added to the increased costs of the means of production augments the insecurity of results for farmers producing stress. The agricultural sector is the most damaged but the most supported by CAP as well. In the years to come, some stakeholders believe that a change toward less hydro-exigent cultures will be seen.

Policy: The CAP 23–27 strategic regional plan is the most influential for rural development. It heavily promotes biodiversity and natural resource use through measures for the cultivation and breeding of species typical of the regional culture or with particular genetic value. Interventions for the conversion of arable land to permanent pastures and payments for the maintenance of natural and forest areas (Ministero delle Politiche Agricole Alimentari e Forestali, 2022).

8.3.5 Response

The soil is considered and managed in different ways, depending on the policy level considered. The policy framework on soil appears not to be fully aligned and harmonized at different levels (national and regional), but a discussion regarding this theme is ongoing. A unique national legislation on soil does not exist yet in Italy.

Land consumption: For what concerns the Po Valley region, the Regional Law (L.R. 24/2017) on land management would represent another step to reduce the consumption of soil.

Nitrate: Nitrogen distribution through fertilizers is limited by a specific law (REGOLAMENTO REGIONALE IN MATERIA DI UTILIZZAZIONE AGRONOMICA DEGLI EFFLUENTI DI ALLEVAMENTO, DEL DIGESTATO E DELLE ACQUE REFLUE, 2017) limiting fertilizers to 1%, and it identifies the areas and the periods in which the distribution is allowed below, considering specific limits that depend on the vulnerability of the territory considered.

Soil policy: In Italy, some matters of legislation are granted by the state to the regions; in the 117th article of the Italian Constitution (Constitution of Italy, 1947), it is stated that legislation on the agricultural topic belongs to the regional administration. Each region declares its own soil laws. Additionally, changes to the Italian constitution were made. To the 9th article has been added the “protection of the landscape, the biodiversity, and the ecosystems for the interest of the future generations”. In the 41st article, among the rights and duties of the citizens regarding private economic activities, the sentence “in a way that does not damage the health and the environment" is mentioned, and it must be coordinated to pursue not only the social interests but also “the environmental goals." (Constitution of Italy, 1947)

In Emilia-Romagna, the regional law L.R. 24/2017 (Regional disciplinary on protection and use of the territory) introduced a maximum of 3% of consumable land, consequently reducing regional land potentially by 70% of the hectares of transformable land. The law takes effect on January 1, 2024.

The soil protection measures for regional development include five Italian eco-schemes. These are aimed at increasing cover crops and improving grazing practices on tree crops and fodder production systems with crop rotations, sod seeding, and no tillage operations (Ministero dell’Agricoltura della Sovranità Alimentare e delle Foreste, 2023). In addition, the strategic plan for CAP 23–27 of Emilia-Romagna comprises an action-based payment per hectare of arable land for the adoption of sod seeding practices and no tillage, counteracting soil degradation, boosting its resistance toward erosion and compaction, contrasting soil organic matter loss, optimizing fossil fuel resource use, increasing the soil capacity for water absorption and retention, and reducing the CO_2 emissions due to soil aeration. Regarding the SOM, the strategic plan promotes practices that increase its content by distributing manure and organic matter-containing fertilizers in place of products with a low content of organic carbon (Ministero delle Politiche Agricole Alimentari e Forestali, 2022).

Awareness: The growing awareness and knowledge regarding soil and related management, environmental quality, and human health, coupled with the theme of innovation and farm management, has influenced the formation of many farmers and companies' approaches.

8.4 Conclusions

According to the stakeholders, it would be useful to improve the research on conservative practices and surrogates of manure. Technology is supporting the farming activity of the precision farming systems that have seen an increase. It is vital to co-create knowledge and transfer it, while maintaining and improving it will be crucial to countering the pressures.

On tomato production, precision farming technologies allow the use of remote sensing tools to investigate crop needs and photo traps for insects, coupled with AI for specimen recognition. For this crop, the innovative agricultural practices that are being tried for the majority are strip tillage and green manure.

Furthermore, the need to create MRV (Measurement, Reporting, and Verification) methodologies for monitoring and result verification has emerged. MRVs are a multiple-step methodology for assessing the greenhouse gas emission reductions obtained due to an evaluated practice or mitigation activity, followed by reporting to a third party (The World Bank Group, 2022).

Carbon farming should be further investigated as it could result in new opportunities for agricultural businesses, together with the provision of ecosystem services, increased contribution to soil organic matter content, reduction of CO2 emissions, and climate change mitigation, for example, improved soil capacity for water absorption and retention.

The soil loss due to soil sealing highlighted the need for dedicated legislation for soil protection. In this context, the stakeholders’ interviews have pointed out high expectations for the European soil law and the consequent national adaptation.

Finally, the implementation of innovative tools such as living labs and lighthouse farms that cooperate with the regional government and form a network with the main stakeholders could help the farmers receive and share scientific and technical support and information otherwise outside their possibilities.

8.5 References

Arpae, & Regione Emilia-Romagna. (2023). *Bollettino nitrati e aria n.39/2022-2023* (Vol. 0).

Fanfani, R., & Boccaletti, S. (2020). *IL SISTEMA AGRO-ALIMENTARE DELL ' EMILIA-ROMAGNA - Rapporto 2020*.

Ministero dell'Agricoltura della Sovranità Alimentare e delle Foreste. (2023). *Gli ECO-SCHEMI 2023-2027 , UNA NUOVA OPPORTUNITÀ PER L ' AGRICOLTURA ITALIANA*.

Ministero delle Politiche Agricole Alimentari e forestali. (2022). *Relazione 2021 sul piano strategico nazionale della PAC*. *i*. https://www.reterurale.it/downloads/PSP_Italia_15112022.pdf

Regione Emilia-Romagna. (2015). *Consumo di Suolo e Pianificazione. Conoscere per decidere. Report del territorio #01.*

REGOLAMENTO REGIONALE IN MATERIA DI UTILIZZAZIONE AGRONOMICA DEGLI EFFLUENTI DI ALLEVAMENTO, DEL DIGESTATO E DELLE ACQUE REFLUE, (2017).

Constitution of Italy, (1947). https://doi.org/10.1080/19962126.2008.11864961

Tarocco, P., Aprea, A., & Regione Emilia-Romagna. (2021). *Carta dei suoli della regione emilia-romagna*.

Tarocco, P., Calzolari, C., & Ungaro, F. (2021). *Note illustrative 2021*.

The World Bank Group. (2022). *What You Need to Know About the Measurement, Reporting, and Verification (MRV) of Carbon Credits*. https://www.worldbank.org/en/news/feature/2022/07/27/what-you-need-to-know-about-the-measurement-reporting-and-verification-mrv-of-carbon-credits

Viaroli, P., Ferrari, C. R., Benzi, M., Mazziotti, C., Naldi, M., Nizzoli, D., Soana, E., & Rinaldi, A. (2018). *VARIAZIONI RECENTI DELLO STATO TROFICO DELLE ACQUE COSTIERE DELL ' EMILIA-ROMAGNA RECENTS TRENDS OF TROPHIC STATUS IN COASTAL WATERS OF EMILIA-ROMAGNA IN RELATION TO ANTHROPOGENIC PRESSURES*. *25*, 2–18.

9 Organic Mixed Farming East: Del-Alföld, Hungary

Judit Berényi-Üveges (ÖMKi) judit.berenyi.uveges@biokutatas.hu, *Korinna Varga* (ÖMKi) korinna.varga@biokutatas.hu

9.1 Regional Information

In historical times, a great proportion of the territory of this region was covered by water, either periodically or permanently. There were small waterways, lakes, and ponds with different land uses, having more grass, wooded pastures, and small spots of wetlands. In the 19th century, the need for navigable rivers and the production of grain crops resulted in the regulation of large rivers and the later establishment of drainage canals (Figure 9-1). In the territory between the Danube and Tisza rivers, these changes induced unfavorable processes, deteriorating soils and drying up the region due to sandy soils with low water holding capacity. This tendency was accelerated by climate change in subsequent decades.

Figure 9-1: Water catchment system of the Del-Alföld, Hungary

Since the 1990s, many people have realized that one of the solutions is not draining water but keeping it in place, which helps farmers maintain agricultural production—a challenge without irrigation. As the risk of flooding and inland water is currently low but the risk of sandstorms and natural fires has increased, many of the local farmers wish to keep water in temporary reservoirs and canals instead of draining it. Refer Table 9-1 for additional information.

Sustainable soil use and regenerative agriculture practices, such as increasing soil organic matter, enhancing soil biological activity, and improving soil structure, can help keep agricultural practices profitable on the one hand and protect the environment on the other. Some other measures on water management, for example, the restoration of wetlands, may help improve water balance. There are already some civil movements to help farmers find a way out of this situation. They plan to work on a changing water management concept and on the application of new cropping and soil management methods and other tools to help conserve water in the landscape and in the soil to maintain profitable farming while producing healthy food.

Table 9-1:Regional Information about Del-Alfold, Hungary

Dominant land use:	cropland, field crop production
Secondary land use:	grassland with extensive livestock farming, fruit, and vine
Climatic Zone:	IPPC climatic zone: Warm Temperate Dry
Soil WRB classification:	Arenosols, Cambisols
Soil type:	quicksand, humus sand
Dominant topsoil texture:	sand, loamy sand
Soil threat(s):	Wind erosion and desertification due to climate change and historical change in water management.
Policy Strategy:	The most important policy document is the national Common Agricultural Policy (CAP) Strategic Plan.
Representative regions:	It can be representative of the sandy part of Szabolcs-Szatmár Bereg county in Hungary. It can also be a sample of regions having drought issues on sandy soils.

9.2 Stakeholder Interaction

We started with collection of literature of different categories including scientific papers, online newspapers, policy documents and webpages. In the meantime, we contacted one of the well-known advisors in the region, the Kujáni family who became our local partner. They have a farm in the region mostly growing fruits and working as advisors on CAP soil fertility management and pest control. They are active in the regional Chamber of Agriculture and Chamber of Plant Protection Experts. They work with many farmers and have a good connection with authorities as well. They helped us identifying stakeholders and organising the workshop. They also served as interviewees because they have a good overview and experience in the problems of the region.

During interviews, we sticked to the questionnaire provided by the work package leaders. We left out some of the questions that we felt not relevant or not needed (clarifying questions). Interviews also helped us to plan the workshop. We focused primarily on the workshop as this gave possibility to get opinions from different stakeholders and learn from their interaction as well. To make it attractive for farmers and advisors, we organised some introductory presentations on topics of interest: one on soil related measures in the new CAP presented by the main soil expert of the Hungarian Chamber of Agriculture and the other was about water management plans in the region presented by the Regional Authority for Water Management and Protection. Other presentations focused on policy context and methodology after introducing PREPSOIL and the Soil Mission. The concept of living labs and advantages being a member in a living lab were also discussed. A presentation summarising the soil challenges of the region made by our local partner. We planned 2 parallel sessions for interaction. One of them was focusing on soil management challenges and possible solutions, the other on water management issues and generally future visions of the region. We wanted all participants to contribute to both topics so this interactive session was repeated with switching participants. There were 30 participants from different stakeholder groups (Figure 9-2)and they participated actively during discussion and provided valuable inputs for soil needs assessment.

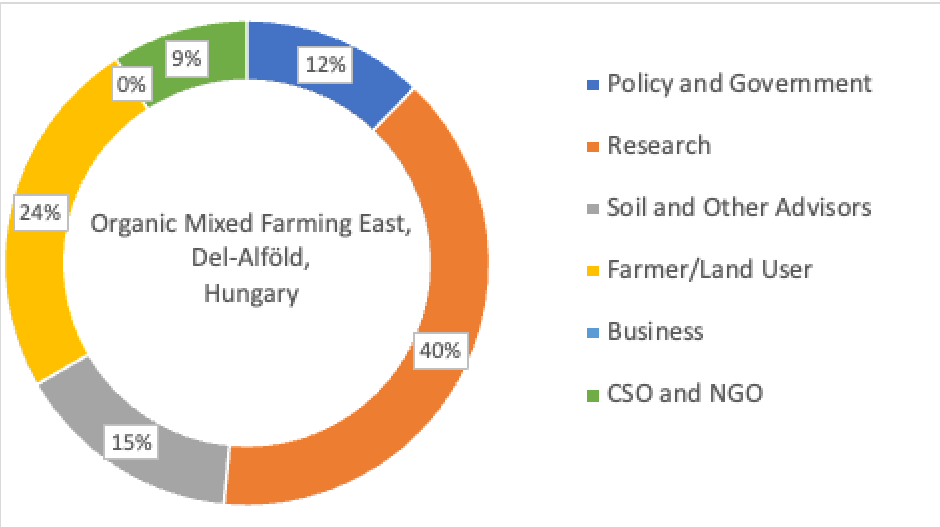


Figure 9-2:Stakeholder interaction in Del-Alfold, Hungary

9.3 Soil Needs Assessment

9.3.1 Drivers

Biophysical drivers: The selected region is a part of the Sand Ridge that stretches across the Great Plain in the Danube-Tisza interfluve. According to the FAO forecast, the Sand Ridge is threatened by aridification. This process is due to the effects of climate change and human activities in the Danube-Tisza Interfluve. This area has been identified as a vulnerable region to desertification, according to the UN Convention to Combat Desertification. Groundwater level changes are the main driving force of biophysical and geographical processes in the area (Kertész et al., 2001).

The majority of researchers agree that the main problem is climate change (warming and decreasing precipitation and changing precipitation patterns). This is followed by water extraction and increasing water consumption, then changes in land use (intensive crop production, afforestation), and water management (Pálfai, 1994). In the 1980s, the aridification process intensified; from the early 1970s until the late 1990s, an extremely serious drought period was registered. Due to the lack of rainfall, the moisture content of the soil decreased significantly (Kertész et al., 2001; Hoyk, 2006; Rakonczai & Kovács, 2006). Meteorological studies of the last 130 years showed that the amount of precipitation decreased by almost 1 millimeter per year on average (total of 80–100 millimeters). Based on studies of climate change models, aridification will continue to increase in the future, and its effects will become more and more noticeable (Kőszegi, 2019).

This biophysical driving force will continue to be active in the future; its process is irreversible, but its effect can be mitigated (Rakonczai & Ladányi, 2010; Hoyk, 2020).

Socioeconomic drivers: In addition to the lack of precipitation, the anthropogenic effects are also important. The Sand Ridge has reached its current form thanks to human activity (Kőszegi, 2019). The human interventions of the last 150 years, such as river regulations of the 18th and 19th centuries, draining marshes, and flood protection measures, all contributed to the change of the landscape (Kertész et al., 2001). On the one hand, this primarily increased the number of habitable and cultivable areas; on the other hand, it transformed the agricultural production structure. Livestock breeding was replaced by crop production. Quicksand was tried to be bound with afforestation, planting vineyards, orchards, and other horticultural crops, but all of them require a lot of water, which resulted in unstable land use (Farkas, 2006).

Although agriculture still provides a secure livelihood for many people in the region, more and more people give up farming. Increasingly difficult conditions, drought, unpredictable rainfall distribution, and declining crop yields all contribute to their decision. All around Europe, the population is aging, and this region is even more threatened. The farming community has been aging, which leads to a labor shortage and worsens future opportunities (Kőszegi, 2019). The aging and decreasing population puts pressure on labor markets and brings new challenges. (Demography Report: "The Impact of Demographic Change in the Changing Environment,", 2023)

The region's competitiveness has been below the national average for a long time, and if a solution cannot be found, further migration is expected. In the past decades, the safety of agricultural production has decreased, the condition of the farmsteads is getting worse, emigration of young people has ceased, and high unemployment has become normal in the periphery (Kőszegi, 2019).

Workshop participants and interviews validated these findings and highlighted the exacerbating effects of inappropriate policy measures. The Common Agricultural Policy gave subsidies based on land that was cultivated and cash crops produced on it, which encouraged farmers to increase their cultivated land by chopping down hedges and tree rows along fields. One of the beneficial features of tree rows is the reduction of wind speed. Without them, strong winds can pick up sand and soil particles from uncovered surfaces.

9.3.2 Pressures

The consequence of dry periods and water management focusing on drainage is the reduction of the groundwater level and the transformation of the soil. The lack of water greatly affects the process of soil formation; furthermore, it also causes difficulties in agricultural production. In the investigated area, a decrease in biodiversity can be observed; saline habitats are being destroyed, and the water has disappeared from lakes for decades. Farmers in interviews mentioned an increasing number of serious wind erosion events damaging crops and infrastructure. The sandy parts of the higher areas are barren, and the drought causes sandstorms and bushfires. The increase in salinity, wind erosion, and reduction of the productive layer are all consequences (Cserni & Füleky, 2008).

As a result of changes in water regime and land use, the arable land area has increased, but the region has dried up. Canals were constructed to drain water from small ponds and wetlands to provide more land for production. More arable land resulted in intensive crop cultivation, and a decline in soil physical properties increased the risk of soil erosion by water or wind. In affected areas, desertification is likely to become irreversible unless we change land use and soil management.

Long-term planning is missing from the thinking of stakeholders. Loss of soil quality significantly affects the environmental sustainability of the soil and the economic sustainability of farming businesses. In the opinion of many, moving to the cities is the easiest solution. Locals clearly see the cause of the problem, which they cannot solve alone. Those who have no choice but to stay run into new problems, while there is a lack of manpower, lack of resources, lack of expertise, and the inability to adapt to a new situation when they learned everything from their parents.

Melioration activities, inland water drainage canals, afforestation, land use, and unauthorized water extraction resulted in a decrease in the groundwater level. The situation is complicated by the irrigation of plantations and intensive plant cultures, as well as the higher water consumption of settlements. Drought further increases water use, which further lowers groundwater levels (Kovács et al., 2017).

Based on model calculations, in the next 90 years, the amount of precipitation will decrease and the number of consecutive dry days will increase. The decrease in groundwater level was documented by different methods, including the analysis of data from the observation well network and modern geospatial information (GIS) methods (Buzetzky, 2012; Kohán & Szalai, 2014).

9.3.3 State

Biophysical situation: In the area of the region, the soil consists mostly of sand (65%), which is, in majority, quicksand, and in smaller parts, humus sand soil with poor productivity. The climate is continental. The daily temperature fluctuation and the number of sunshine hours are very large. The water has already disappeared from most of the natural still waters and saline lakes. The present appearance of the region is the result of human intervention (Buzetzky, 2012).

Since water is a limiting factor in agricultural production, water regulation was necessary. The ridge is 50–60 meters higher than the course of the Danube and the Tisza, without natural water flow. It is a water-stressed region, and it has weak runoff. The purpose of melioration was primarily to protect against inland water, but in the absence of natural watercourses, the created canals are also suitable for irrigation. The canal network was built gradually with a length of 200 km, but the problem is that irrigation only provides a solution for improving the soil of horticultural crops that require a small area (growing equipment, foil tents, plantations) (Cserni & Füleky, 2008; Buzetzky, 2012).

Farming practices use intensive tillage with plowing and disking that deteriorate soil structure, soil organic matter and biodiversity. Sandy soils have a limited capacity for the formation of soil aggregates as they contain a limited amount of inorganic colloids.

Socioeconomic situation: The importance of agriculture in the structure of the region's economy has been decreasing, but it is still the dominant sector. The environment and the structure of the economy have been changing significantly in the last few decades. Animal husbandry was replaced by crop cultivation. The main form of utilization of the sandy soils is still crop cultivation in fields without irrigation (40%), but the territory of arable lands is constantly decreasing. The development of orchards and vineyards would be justified on the arenosols with higher organic matter content. (Cserni & Füleky, 2008).

The system change (or change of regime) of 1990 also had a great impact on agricultural property and market conditions. It was difficult to transform the structure that was adapted to mass production and adhered to traditions. The industrial and service activities that could support the development are not present. The low rate of investments and the lack of strong companies show low competitiveness in the region (Kőszegi, 2019).

Regardless of the results of the investigation of relevant drivers and pressures, secondary school students from the workshop mentioned the problems of outdated teaching materials and equipment they can use during practices. Therefore, they are not able to access modern technology and learn how to use it. They miss those skills when they start working in real farm circumstances, many of them on their family farm. They wish to see new trends in agriculture within the framework of their studies. They would be happy to be involved in technology development and applied research.

9.3.4 Impacts

The effects of water shortages can be seen on vegetation and dried-up saline lakes, but they also have a great impact on agricultural production. Since the 18th and 19th centuries, most of the sand and steppe grasslands have disappeared, and the original landscape has been changing dramatically as a consequence of cultivation and afforestation. The natural habitats have decreased in the last 30 years due to plowing and tree plantations (Biro et al., 2011).

Previously, the aim was to increase the territory of arable lands, orchards, vineyards, and forests, but now the opposite is happening. Arable lands and vineyards have been decreasing, while forests and areas taken out of cultivation are on the rise. The afforestation has an adverse effect on the water balance because it takes in more water than grasslands and meadows. The drying up of saline lakes and the increase in salinity have been changing the vegetation (Hoyk, 2006).

The high dependence on water causes further socio-economic problems. Abandoned farms and emigration to larger cities are increasing. Young people have been leaving the region, and the population is getting older, contributing to the weakening tendencies of the region's economic competitiveness (Pálfai, 1994; Faragó et al., 2010; Kovács et al., 2017; Kőszegi, 2019). Kőszegi (2019) examined environmental sustainability among young farmers (younger than 40 years) on special problems of the sand dunes. During the non-representative survey, she reached 124 farmers. She investigated how they judge their farm according to environmental sustainability. One of the most striking problems she found is that they do not consider aridification to be the most important issue. Owners primarily identify labor shortages as the biggest risk that influences the future management of their farms. Most farmers generally do not realize that their current farming practices are environmentally unsustainable.

As a result of socio-economic changes and the lowering of the groundwater level, there are social problems such as high unemployment, marginalization, aging, and migration. In addition, wasteful water consumption, unsustainable agricultural management, and the undereducation of prospective farmers all result in the region's competitiveness being below the national average for a long time.

9.3.5 Response

More and more people are paying attention to the problems of the region, and the problem of lowering the groundwater level in the Danube-Tisza Interfluve has been a frequent topic of the Hungarian Parliament since the 1990s. Social movements and national and local collaborations have already been set up. There were some initiatives that had a promising start, but they ceased working as governmental support was over.According to Pálfai's (1994) summary study of the causes and options for improvement, he classifies the practical tasks into two main groups: better adaptation to water deficit conditions and water replacement from an external water source. Adaptation offers limited opportunities; however, water replacement carries risks due to unexpected effects. Most people agree that keeping precipitation in place would be one of the most important measures (Pálfai, 1994; Faragó et al., 2010; Kovács et al., 2017).

There is a local initiative called the Water of Dongér-Kelőér Association consisting of local farmers of three settlements (Szank, Móricgát, and Jászszentlászló) that has already started a small water retention project. (Sample project: "The Kiskunság cries for water", 2021). Farmers in the region would like to have organization and planning along product chains. A short supply chain helps them produce added-value products while having personal contact with consumers. Added-value products need more investment and knowledge to process their raw materials, but they can provide more income than selling the crops unprocessed. Communication with consumers about how food is produced and how crops are grown is important. Therefore, they should be sensitized to the challenges in agriculture and build links to the community of farmers who produce their food.

Recently, the National General Directorate of Water Management launched a project called "Improvement and restoration of the water-deficient ecological condition of the Danube-Tisza Sand Ridge" that tries to find a solution to save water-dependent habitats from a water management point of view. Workshop participants appreciate the efforts of agricultural policy to promote change, but the ways of communication and implementation have to be improved.

9.4 Conclusions

Interviewees and workshop participants agreed that the concept of water management should be changed: instead of draining away water, stakeholders should try to conserve water in the landscape by closing drainage canals to store water, restoring and establishing ponds in lower lying areas, and in soil by increasing its water holding capacity.

Workshop participants emphasized that the focus should shift toward restoring soil fertility and soil health and increasing water holding capacity. Because the region is covered by sandy soils, there is a limited amount of mineral colloids that help structure formation. Increasing organic matter content and soil biology is an important aim. Reducing soil disturbance, reducing tillage, and providing cover on the soil surface are important principles, and there is a need for farmers to explore what techniques, considering tillage, crops, and crop varieties, including local varieties used as cash crops and cover crops, perform well in sandy soils at drought risk in this region.

To help successful production on fields, other landscape elements are also needed, so they think that restoration of hedgerows and trees is also important, for example, controlling wind speed and providing habitats for wildlife and biodiversity that helps pest control. Another important aspect mentioned was organic matter management and recycling of resources, focusing on manure management and composting organic residues. There are solutions, but many of them are difficult to apply due to legal provisions. Communication between local water management authorities has already started. Clarification of needs and ways of handling different interests in decisions about water management must be worked out, if need be, by suggesting modifications to relevant legislation.

9.5 References

Biró, M.-Horváth, F.-Révész, A.-Molnár, Zs.-Vajda, Z. (2011). Száraz homoki élőhelyek és átalakulásuk a Duna-Tisza közén a 18. századtól napjainkig. Természetvédelem és kutatás a Duna–Tisza közi homokhátságon, Rosalia 6 (2011), pp. 383–421.

Buzási, A.-Pálvölgyi, T.-Esses, D. (2021). Drought-related vulnerability and its policy implications in Hungary. Mitig Adapt Strateg Glob Change 26, 11

Buzetzky, B. (2012). Komplex környezeti monitoring vízháztartási viszonyok elemzése a Kiskunsági-Homokhát területén, VI. Magyar Földrajzi Konferencia 81-91. In Nyári Diána (szerk): A VI. Magyar Földrajzi Konferencia, a MERIEXWA nyitókonferencia és a Geográfus Doktoranduszok Országos Konferenciájának Tanulmánykötete.

Cserni, I.–Füleky, Gy. (2008). A Duna-Tisza közi homokhátság talajainak vízgazdálkodása, Talajvédelem különszám 2008 (szerk.: Simon L.) Talajtani Vándorgyűlés, Nyíregyháza, 2008. május 28-29.

Faragó, T.-Láng, I.-Csete, L. (2010). Climate change and Hungary: mitigating the hazards and preparing for the impacts. Report of the VAHAVA project.

Farkas J. Zs. (2006). Művelési ágak változásai a Homokhátságon. A falu 21. évf. 2. sz. pp. 79-87.

Hoyk, E. (2006). A szárazodás hatása a vegetáció alakulására homokhátsági szikes tavak példáján. Táj, környezet és társadalom/Landscape, environment and society. Szeged: SzTE, 293-303.

Hoyk, E. (2020). Tasks and suggestions for the adaptation tot he climate change in Kecskemét, Gradus (7) 2.

Iványosi Szabó, A. (1994). A Duna-Tisza közi hátságon bekövetkezett talajvízszintsüllyedés hatása természetvédelmi területeinkre. In: Pálfai I. (szerk.) A Duna-Tisza közi hátság vízgazdálkodási problémái. – Nagyalföld Alapítvány kötetei 3. Békéscsaba, pp. 77-87.

Kajner, P.-Molnár, G.-Botos, I. Cs. (2017). Jövőnk a víz - Tájgazdálkodás - a jövedelmező mezőgazdaság hosszú távú feltétele – Vízhiány a Homokhátságon. Szövetség az Élő Tiszáért Egyesület kiadványa.

Kertész Á.–Papp S.–Sántha A. (2001). Az aridifikáció folyamatai a Duna-Tisza közén. –Földrajzi Értesítő L. évf., 1-4. füzet, pp. 115-126.

Kohán, B. (2014). GIS-alapú vizsgálat a Duna–Tisza közi homokhátság szárazodásának témakörében. Doktori értekezés. Eötvös Loránd Tudományegyetem, Természettudományi Kar, Földtudományi Doktori Iskola.

Kohán, B.-Szalai, J. (2014): Spatial analysis of groundwater level monitoring network in the Danube–Tisza Interfluve using semivariograms. Hungarian Geographical Bulletin 63 (4) (2014) 379–400.

Kovács, A. D.–Hoyk, E.–Farkas, J. Zs. (2017). Homokhátság – A semi-arid region facing with complex problems in the Carpathian Basin. European Countryside 9:(1) pp. 29-50.

Kőszegi, I. R. (2019). A környezeti fenntarthatóság fontosságának vizsgálata a homokháti fiatal gazdák körében (egy primer kutatás részeredményeinek ismertetése). Gazdálkodás, 63 (1) pp. 40–57.

KSH (2019). Statisztikai tükör, a fontosabb növények vetésterülete. Központi Statisztikai Hivatal.

Pálfai, I. (1994). Összefoglaló tanulmány a Duna-Tisza közi talajvízszint süllyedés okairól és a vízhiányos helyzet javításának lehetőségeiről. A Nagyalföld Alapítvány kötetei 3. Békéscsaba. pp. 111-125.

Publications Office of the European Union (2023): A demograpy report, Manuscript: "The Impact of Demographic Change in the changing environment"

Rakonczai, J.–Ladányi Zs. (2010). A sejthető klímaváltozás a Duna-Tisza közi Homokhátságon. Forrás Folyóirat, 42 (7-8) pp. 140-152.

Sample project (2021): "The Kiskunság cries for water" - A Kiskunság vízért kiált. Sürgősségi beavatkozási terv a homokhátság vizeiért. Jászszentlászló – Móricgát – Szank térségében vízvisszatartást, talajvízszint növelését célzó tájgazdálkodási mintaprojekt.

UNCCD (2006). Second National Report of the Republic of Hungary on the implementationof the United Nation Convention to Combat Desertification. Budapest: Ministry ofEnvironment and Water of the Republic of Hungary.

Zsákovics, G.-Kovács, F.-Kiss, A.-Pócsik, E. (2007). Risk analysis of the aridification-endangered Sand-Ridge area in the Danube-Tisza Interfluve. Acta Climatologica et chorologica. Universitatis Szegediensis, Tomus 40-41, 2007, pp. 169-178.

10 Mixed Farming North: Trondelag, Norway

Kamilla Skaalsveen, Adam O'Toole (NIBIO)

10.1 Regional Information

Agricultural soils cover only three percent of the total land area in Norway, and of that, only a third [KB1] is suitable for producing food grains. The total area of the Trøndelag region is 42 190 km2, and between four and five percent of this area is used for agricultural purposes (Area barometer, NIBIO (2022)). Trøndelag has a population of around 446 000 residents and is one of Norway's largest agricultural regions and the northernmost grain county (Knutsen et al. 2017).

Trøndelag is situated in "Mid-Norway" and located at around 64° N (Figure 10-1) The mean average temperature is 5 °C, and annual precipitation is around 1000 mm (The Norwegian Meteorological Institute, 2020). The cold climate therefore largely affects agricultural production, with a short growth season and small weather windows for tillage and harvest.

Intensive land use and poor drainage represent typical soil pressures in Trøndelag, while less intensive agricultural methods (e.g., no-till, reduced tillage) and measures (e.g., cover crops) can be hard to establish due to the cold climate and short growth season. Many farmers in Trøndelag therefore associate these measures with yield losses and higher economic risk (Skaalsveen et al., 2022). Another common argument is that the farmers do not have enough time or money to change practices (Skaalsveen et al., 2022). There was an increasing interest in cover crops in Trøndelag (and in Norway in general), but relatively little knowledge exists on how to succeed with this measure under the given climatic conditions, making the economic risk too high for most farmers to implement it. Farmers in Trøndelag also called for more predictable subsidy arrangements and schemes so that investments to change practices and implement measures will not involve high economic risk (Skaalsveen et al., 2022).

Soil sealing due to the development of infrastructure and residential areas is an important challenge and soil threat in Trøndelag. Examples are the expansion of the railway from a single to a double line and political pressure to increase the width of the motorway (E18) to cater for more efficient commuting and transport logistics. The E18 runs through the prime agricultural flat land areas in North Trøndelag, such as Skogn/Levanger (Table 10-1).

Climate change is causing more precipitation in Trøndelag, reducing the time window for harvesting and other field operations, while more intense events are leading to more flooding and erosion. In a report by Lågbu et al. (2018) about soil statistics in different regions of Norway, they state that the main reason for why soils in Trøndelag are downgraded according to the soil quality classification system is the lack of soils ability to infiltrate or transport surplus water. An important contributor is the high occurrence of soils that originate from marine clay. The water is often led through the topsoil but slowed down by less permeable subsoils with low conductivity. Climate change has, and will probably continue to, increase the growth season in the Trøndelag region, which also means potential new opportunities for farm production in the region.

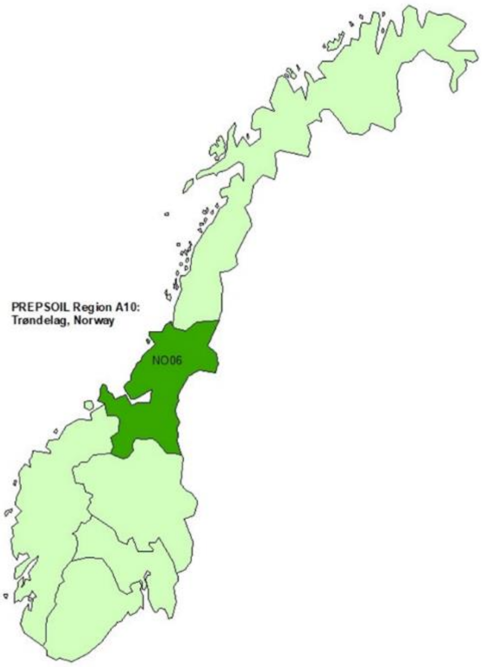


Figure 10-1:Map of Trøndelag, Norway

Table 10-1:Regional information of Trøndelag, Norway

Dominant land use:	Commercial forestry and Agriculture (mixture of pastures and cropland)
Secondary land use:	Natural/forestry, mountains
Climatic Zone:	Temperate: The average temperature in January is 0°C by the coast and between -2°C and -5°C in the lowland and around -10° in valley regions further east. The annual precipitation is around 1000-1200 mm by the coast and generally around 800-1000 mm in other parts of the region (The Norwegian Meteorological Institute, 2020).
Soil WRB classification:	Stagnosol (dominant WRB), Gleysol, Cambisol, Arenosol, Histosol, Podzol, Leptosol, Regosol, Phaeozem, Fluvisol, Planosol, Umbrisol

Soil type:	Agricultural soil
Dominant topsoil texture:	Silty loam/clay loam
Soil threat(s):	High precipitation rates, poor drainage, soil compaction (saturated soil during harvest), soil erosion, soil sealing.Part time farming, intensive agriculture, limited time to spend on farm work, sometimes lacking/to small economic incentives, high pressure on agricultural land.
Representative regions:	Cereal production and mixed farming at high latitudes.

10.2Stakeholders Interaction

Two workshops were organized in Trøndelag March 27th and 28th 2023. The first workshop took place at Skjetlein, an agricultural high school close to Trondheim city (the county capital of Trøndelag). The second workshop took place at Mære, which is another agricultural high school around 120 km north of Skjetlein. The two schools are both a part of Grønt kompetansesenter (Green Competence Center) that is aiming to establish an agricultural soil health living lab in the region with the working title of "the Trønder's living soil lab" (Trøndernes levende jordlab). This workshop was therefore also intended to be a first step in the process of bringing various stakeholders together to discuss the need for a soil health living lab in Trøndelag.

A total of 25 participants took part in the workshops: 15 at Skjetlein and 10 at Mære (Figure 10-2). Among the participants were both farmers and representatives from agricultural schools (Skjetlein high school, Mære high school (Green Competence Center) and Val nature high school), research institutes (Ruralis, NIBIO), the Norwegian Extension Service, the County Governor in Trøndelag, Municipalities and a drone company.

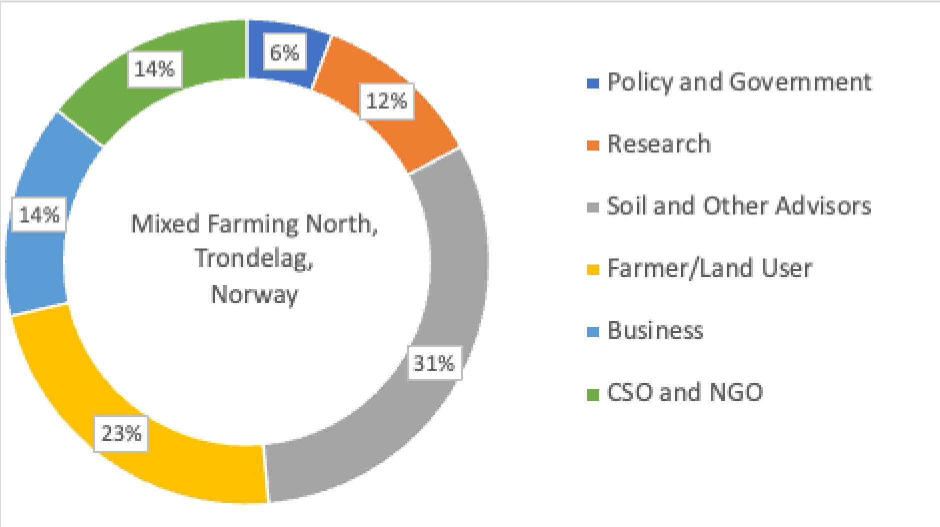


Figure 10-2:Stakeholder interaction in Trondelag, Norway

10.3 Soil Needs Assessment

10.3.1 Drivers

Political and legislative drivers: Political decisions affecting pricing and agricultural agreements and settlements were highlighted as important driving forces with great influence on agriculture in Trøndelag. The "Canalization Policy" is an important premise provider in Norwegian agriculture, affecting agricultural structure and decisions. The aim of this policy (launched in the 1950s) was to make the best possible use of all arable land. The land that is best suited for grain and vegetable production should be used for that purpose only. These are mainly lowland and coastal areas with a milder climate and the best-quality soil. In areas that were less suited for grain and vegetable production, farmers were encouraged to hold livestock. Sheep and cattle can graze on steep valley sides, forests, and mountainous areas and thus contribute to the full utilization of soil resources. In other words, the canalization policy was aiming to make Norway as self-sufficient with agricultural goods as possible.

The sum of instruments and market forces is greatly influencing Norwegian agriculture. The strongest implementation tool is the yearly agricultural subsidy settlement [KB2], negotiated between the Norwegian government and the two farmer's unions. Here, milk quotas are adjusted, which can influence the market price of milk, and subsidies for a variety of interventions are agreed upon, including environmental and climate actions in agriculture, R + D funds for applied agricultural research, and general subsidies that incentivize the continuance of food production in Norway.

The current legislation was highlighted as a factor that can indirectly affect soil health negatively. Some said that they experienced a great distance between decision-makers and farmers, as well as a poor link between academic research and practice. Norwegian farmers can apply for production subsidies, which are an important source of income, and subsidies for implementing environmental measures, such as abstaining from plowing the soil in the autumn, which may increase soil erosion risk during snow melting in the winter. These schemes were, by some, perceived as little practically oriented. Certain measures were not experienced as feasible due to the given rules for how they should be carried out. Consumer preferences towards chicken and pork and away from beef have also influenced marked development over the last 20–30 years.

Biophysical drivers:The weather is an important driver affecting agricultural production in Trøndelag, with a short growth season and small weather windows for tillage and harvest. In addition, climate change has caused more unpredictable weather and led to more precipitation, more intense precipitation events, and flooding. Some of the grain areas are also landing and feeding sites for thousands of migratory geese, which are protected under law and can graze down a lot of freshly germinated cereal crops before they fly north in the summer.

The undulating landscape is another biophysical driver that contributes to taking agricultural land out of use, e.g., due to challenging topography, location, and the shape and small size of fields. The trend of farmers getting larger and heavier equipment is also a challenge in Trøndelag. It is common that farmers or farm contractors take on snow removal as a side job, as they have tractors that can be used for the purpose. Removal of snow does, however, require that the farmer have a large enough tractor to do an efficient job. They might therefore purchase extra-large tractors to remove the snow and use the same tractors on the fields.

Socioeconomic drivers: Farm economy is generally an important driver, forming important premises for how agricultural land is managed but also affecting the “farming culture”. In grain production, in particular, it is common that farmers have full-time jobs alongside farming. As farming in Trøndelag has transitioned over the last decades, many producers with higher proximity to the city have shifted from mixed farming with livestock to grain production only as it is easier to combine with work outside the farm. The wish to work part-time in addition to farming can partly be explained by the general development in Norwegian agriculture, with increasing costs relative to income.

Investing in farm equipment: The economy is also affecting farmers’ ability to purchase new equipment or carry out important upgrades on the farm. Norwegian farming has reached a point where many farmers are experiencing that they either have to "go big" with investments and high loans or stop farming. Lack of time and money were perceived as important driving forces, making it challenging to prioritize soil health and integrate soil health measures into daily operations. Farmers felt that intermediaries in the value chain (e.g., retail chains) end up with a too large portion of the total, contributing to the problem. In addition, varying competence and awareness amongst the end user prevent them from making informed choices regarding where or from whom they buy food and agricultural products.

Tradition is another important driving force in agriculture that largely influences operational decisions. Knowledge is largely "inherited" from the previous generation, and there is no requirement for agricultural education to run a farm in Norway. Management systems affect soil health and functions, and some of the participants believed that a lack of holistic thinking, missing competence, and little knowledge about the negative effects of current practices were important reasons for reduced soil health.

New opportunities from a longer growing season: The agricultural infrastructure is another driver affecting agricultural land use in Trøndelag. An example is the opportunity to produce more grain for human consumption resulting from the longer growth season. In Trøndelag, however, there are no receiving silos for food grain, so it needs to be transported to southeastern Norway. As a result, grain food quality ends up as fodder instead. One innovative farmer has set up his own barley malting facility on the farm and sells his malted barley directly to boutique breweries. It could also be possible for farmers who are producing good-quality food grain to cooperate together to form a storage and milling facility for high-quality flour that is sold directly to the public.

Soil Sealing: The development and decommissioning of agricultural land for residential purposes and cottages, as well as roads and infrastructure linked to these areas, is an important reason for the loss of agricultural areas. This is also partly driven by the increasing population of Trøndelag, which increases the demand for housing and infrastructure.

10.3.2 Pressures

Negative pressures: An important pressure resulting from the Canalization Policy is the rapid decrease of mixed farms (e.g., with both grain and dairy production) in Trøndelag. Removing the animals from the grain areas has led to less crop rotation and increased monocultures of barley, in combination with an absence of manure. Simultaneously, there is a great surplus of animal manure in the areas of gras and dairy/beef.

Farm economics is an important driver that leads to negative pressures and a reduced ability to prioritize soil health. In Trøndelag, there is an ever-increasing proportion of leased land. Leased land is often not maintained in the same way as owned land (e.g., drainage) due to a lack of prioritization from both the tenant and the owner. The reduced willingness to maintain leased land is also connected to a fear of investments that will not pay off (e.g., short leasing contracts) and financial losses.

The absence of crop rotation and crop diversity in the grain areas was also a result of economic pressure experienced by the farmers, as they felt the need to intensify the production, choosing efficiency over diversity, to achieve an economically sustainable production. Less intensive farming methods are often perceived as unprofitable or inefficient in terms of yields. Limited finances also reduce their ability to invest in optimal equipment, affecting the production result as well.

The decreasing number of farmers in Trøndelag means that the same amount of work will have to be carried out within the same narrow time window, but by fewer people. This calls for higher efficiency, often synonymous with larger machinery. The limited time might force farmers to drive on the fields under less optimal conditions, e.g., when the soil is too wet. Larger farm units also lead to more transportation of manure, meaning that the vehicles for manure transport need to be bigger as well.

Soil pressure caused by changing weather patterns due to climate change is further enhanced by the large backlog of drainage in Trøndelag. Restoring drainage systems is both costly and extensive work. Farmers can apply for financial support through regional grants, but they can still be hesitant as they only cover a fraction of the cost. Apparently, the current hydrotechnical systems are also challenged by occasional extreme precipitation events exceeding the capacity of the systems and causing damage. Droughts have on occasion also challenged the farm infrastructure in Trøndelag as irrigation systems are more or less absent from this region (as irrigation is not normally needed). A few years ago, farmers therefore had to provide the grazing animals with fodder over the summer as the gras production was failing.

Lack of knowledge about soil and soil health was mentioned as a negative consequence of the high occurrence of part-time farmers that do not have the time and capacity to (or interest in) obtain new and updated information about soil management practices and measures. The ability to restructure and adjust the agricultural system according to, e.g., a changing climate is very dependent on the farmers' individual ability to adapt. Some might see the need and have the capacity and ability to find new methods and research new ways of farming, while others will stick to what they already know regardless of the consequences. For some, the lack of adaptation might also be a result of a poor farm economy, making change challenging or even impossible.

This "part-time and overtime agriculture" can have negative consequences for the soil, as farmers will have limited time and opportunity to acquire new and up-to-date knowledge about soil health, different management methods, and soil improvement measures. Tradition can also lead to poor management as some farmers are just “doing what they have always been doing”, which might not always be best practice and sometimes prevent the farmer from seeking new methods and solutions.

Positive pressures: Climate change can also have positive outcomes for agricultural production in Trøndelag. Warmer temperatures can lead to a longer growth season and new opportunities related to what types of crops can be produced in the region. A longer growth season might also increase the production output, as some now manage to get three harvests or mows of grass per season instead of the usual two.

The short time window for harvest and sowing might encourage large-scale farmers who are leasing land to consider reduced tillage to save time. Currently, however, there is a trend towards more autumn plowing in Trøndelag as the subsidies for reduced tillage were reduced. The need for efficiency, in combination with more knowledge amongst some farmers about soil compaction, has led to an increased interest in precision agriculture and the development of new (and lighter) technology, such as smaller autonomous tractors, e.g., Auto Agri (www.autoagri.no).

There is an increased interest in locally produced food amongst the general public, which could be beneficial by increasing people’s awareness and interest in how food is produced. There is currently also an increasing interest amongst the public in learning how to grow their own food in gardens or on balconies. This wave could also increase people's awareness of the importance of soils and the link between soil health and human health.

There are currently a couple of biogas companies in Trøndelag requesting animal manure due to the high surplus in parts of the region, potentially turning it into a resource instead of a problem. Apparently, the companies are bidding on the manure and offering farmers good money for it. Bioresidue from the biogas plants can potentially become a valuable resource in Trøndelag and is possibly easier to transport than manure.

Spreading manure by horse is an increasingly used method that can benefit soils as it enables farmers to drive less on their land. Farmers are more aware of the importance of wheel size and pressure to decrease the soil load, which might, to a certain extent, make up for the heavier tractors and equipment.

10.3.3State

Change in quality: The Canalization Policy and the leveling of soils were political decisions from back in time with great impact on the current state of Norwegian soils. Removing livestock from the best grain production areas also reduced access to animal manure, while the leveling of land has impacted both soil erodibility and fertility. Referring to the low diversity and low returns of soil carbon in grain systems, one of the interviewees said: "*A bare field has photosynthesis very few weeks of the year*".

This has resulted in slowly decreasing soil organic carbon contents, impacting both soil fertility, functioning, and resilience (e.g., weather extremes such as floods and droughts) and microorganisms' access to "food" (as straw is heavily degradable and often removed). This might result in an increased need for inputs to maintain yields and lead to more usage of mineral fertilizers. The workability of the soil was also decreasing, requiring more horsepower and effort to till the soil. In livestock areas, however, the manure has to be spread over a smaller area, resulting in a great nutrient surplus.

There was consensus amongst the stakeholders and interviewees that monocultural grain production was negatively affecting the state of soils in Trøndelag, worrying about the negative effects of the low above-ground species richness on soil biodiversity. Nevertheless, many were still of the impression that the soil health in the region was relatively good, but best in the grass and livestock areas. They believed that the state of the soil in Trøndelag was good compared to some soils in Europe (with very low carbon contents) and soils in southeastern Norway, but underpinned that this was because it was "not that long since the livestock and grain production were separated in the region".

Soil compaction has become an important issue in Trøndelag, resulting from a combination of heavier machinery, poorly drained fields, driving on the fields at the wrong time (e.g., resulting from small weather windows, time pressure, larger units, and fewer farmers), and declining organic matter contents, making soils more susceptible to compaction damage. Soil compaction is degrading the soil structure, reducing water infiltration and storage capacity, increasing surface runoff, and increasing the risk of nutrient and soil losses from erosion. The challenges related to soil losses were further reinforced by periods of heavy rainfall.

Change in quantity: Pressure on agricultural land due to other purposes such as infrastructure and residential areas leads to soil sealing and permanent losses of fertile soils. Relocation of agricultural soils as a measure to reduce the negative impacts of development projects has become more common. Some of the participants were uncertain about the effects of such nature interventions and the soils' ability to perform afterwards and therefore suggested that they should be kept to a minimum. Abandoned land also contributes to reducing the total production area. For some producers, such as vegetable farmers, the increasing rates of land on the leasing market might also mean higher accessibility to soils suited for their production, more optimal growth conditions, and opportunities for crop rotation (as these producers are more reliant on crop rotation to reduce the risk of pests).

Other changes: The size of farms is increasing as smaller farmers leave the industry and lease their lands to the farmers who remain and wish to expand their operations. Some of the workshop participants argued that more farmers provide greater impetus for change and that this trend could have negative consequences for new and better farming methods.

10.3.4Impacts

Changes to soil state affect soils' ability to deliver ecosystem services and provide soil functions. Soil compaction and poor drainage can affect soil biodiversity, plant root growth, and soil gas exchange capacity negatively. The ability to infiltrate and store water is also reduced in soils of poor structure, reducing not only the buffering capacity during extreme weather events such as floods and droughts but also the water purification ability. Low crop diversity, but also large distances between trees, bushes, and other vegetation, can contribute further to homogenic and less resilient ecosystems with fewer pollinators and other beneficial organisms.

Large nutrient surpluses in livestock areas can increase the risk of nutrient leaching into the environment. Losses of soil and nutrients caused by surface runoff and erosion from poorly protected grain fields are another contributor to water eutrophication. In Trøndelag, this is particularly unfortunate for the wild salmon populations spawning in local rivers, as they require good water quality.

10.3.5Response

There was consensus that more diversity is key to improving the soil state in Trøndelag by introducing cover crops and crop rotations (e.g., wheat, peas, beans, and oilseed rape). More photosynthesis and "green soil cover" for a larger part of the year would both protect the soil from erosion and increase carbon inputs. Although interest in cover crops was increasing in Trøndelag, there was also a skepticism towards whether they were possible to establish properly at that latitude, calling for more knowledge. More diversity would probably also be beneficial for stimulating more and more diverse soil biodiversity. Stimulating the establishment of permanent grassland is another potential measure to increase carbon storage.

More organic amendments to grain fields were another suggested way of improving soil health in Trøndelag. Increasing the usage of compost is one option, but regulations are currently quite strict, somewhat complicating building new knowledge on the topic. Another option is the organic residues from the biogas facilities in the region, as well as biochar. The residue is possibly easier to transport than manure, creating new opportunities.

More knowledge was requested about different farm equipment and about the status of soil health in Norway (there is a new monitoring program in place that will start mapping soil health across the country shortly). The importance of increasing consumer knowledge was highlighted as well, and co-op farming was mentioned as a way of increasing people's awareness of soils and food production. This is also a way of bringing people together around healthy food. It should be easier for consumers to make informed choices about the food they are purchasing and consuming. A labeling scheme for products produced on the soil's terms could be a way of enabling this, but it is also a challenging task.

Good links between farmers, extension services, decision-makers, and researchers can contribute to strengthening soil health efforts. A soil health living lab for the Trøndelag region is in the formative stages due to this PREPSOIL meeting. The individual farmer needs to be engaged and equipped with enough knowledge to adapt soil health measures to local farm conditions. Regulations related to subsidies also need to be flexible to encourage farmers. One of the interviewees said: "*We need to make sure that it is cooler to be the best agronomist than driving the largest tractor*".

In general, an improved farm economy was seen as a prerequisite for the ability to prioritize soil health through management decisions and maintenance. Stimulating soil health economically is important for change, and one of the interviewees said:"*A lot is dependent on infrastructure and stimulating to the measures that we already know are working. We do not have to invent the wheel again. We know that versatile management is better for the soil*".

10.4 Conclusions

Agriculture in Trøndelag is diverse compared to some other regions of Norway, with a high number of dairy and meat producers, grain producers (mainly barley), and vegetable producers. When livestock was more or less eliminated from the best grain areas some decades ago, the returns of organic amendments to these soils started decreasing. This has resulted in slowly decreasing soil organic carbon contents, impacting both soil fertility, functioning, and resilience (e.g., weather extremes such as floods and droughts) and microorganisms' access to "food".

Soil compaction has become an important issue in Trøndelag, resulting from a combination of heavier machinery, poorly drained fields, and driving on fields at the wrong time (resulting from, e.g., small weather windows, time pressure, larger units, and fewer farmers). An increasing proportion of leased land has contributed to this negative trend. Poor soil structure, in combination with periods of heavy rainfall, results in more surface runoff, erosion, and nutrient and soil losses to the environment.

Soils in Trøndelag could benefit from higher diversity in terms of cover crops and crop rotations, which call for more knowledge about the performance of different species under cold and wet conditions. More species richness would probably also support more diverse and functional soil biodiversity and contribute to increased carbon sequestration. Applying organic amendments such as compost or bioresidue could be an alternative to manure that is easier to transport.

Time and money are important barriers for farmers to prioritizing soil health, and economic incentives are important to enable good choices. Flexible regional policy regulations that support good agronomy and allow farmers to change their practices without high economic risk are important.

Raising awareness amongst both politicians, consumers, and producers is key to getting soil health on the agenda. Establishing platforms where farmers can exchange knowledge and ideas for improved knowledge and information diffusion could be a beneficial way of speeding up learning processes and increasing farmer engagement.

10.5 References

Area barometer, NIBIO (2022). https://arealbarometer.nibio.no/nb/fylker/troendelag/

Bjugan, M., Vasseljen, J., Rye, J., Paulsen, S.K., Jenssen, E. 2022. Økonomien i landbruket i Trøndelag 2020. Utviklingstrekk 2011-2020 – Tabellsamling 2016-2020. NIBIO Rapport 8(22).

Kilden, NIBIO (map service at nibio.no with overview of land use etc.). https://kilden.nibio.no/?topic=arealinformasjon&lang=nb&X=7090015.93&Y=303195.55&zoom=2.0177410254628647&bgLayer=graatone_cache&layers=dmk_dyrkbar_jord&layers_opacity=1,0.75

Knutsen, H., Halland, A., Øvren, E. 2021. Driftsgranskinger i jord- og skogbruk 2021.

Knutsen, H., Sand, R., Kårstad, S. 2017. Kunnskapsgrunnlag for trøndersk landbruk. NIBIO Rapport 3(154).

Lågbu, R., Nyborg, Å., Svendgård-Stokke, S. 2018. Jordsmonnstatistikk Norge. NIBIO Rapport, 4(13). 75 p.

Skaalsveen, K., Øverland, J.i., Bechmann, M., Maurset, M.U., Kvakkestad, V., Wiik, J., Evju, I., Holm, H.N. 2022. Barrierer og muligheter for gjennomføring av vannmiljøtiltak. NIBIO Rapport 8(38). 52 p.

Statsforvalteren i Trøndelag 2023. Veileder: Regionale miljøtilskudd til jordbruket i Trøndelag 2023. Steinkjer 13. april 2023.

The Norwegian Meteorological institute 2020. https://snl.no/Tr%C3%B8ndelag_-_klim

11 Post-Mining: Vzhodna Zasavje, Slovenia

Blaž Repe (blaz.repe@ff.uni-lj.si), Barbara Kostanjšek (barbara.kostanjsek@bf.uni-lj.si) and Naja Marot (naja.marot@bf.uni-lj.si) from the University of Ljubljana

11.1 Regional Information

The Zasavje NUTS 3 region is located in the central part of Slovenia (Figure 11-1) between the capital city of Ljubljana and Celje, the 3rd largest city. It is the smallest Slovenian region in area out of 12 regions (485 km2) and the second smallest in terms of population (56.942 in 2022, or 2.7% of the whole of Slovenia; Statistical Office of the Republic of Slovenia, 2023). The region entails four municipalities: Litija, Zagorje ob Savi, Trbovlje, and Hrastnik (in Slovenia, there are 212 municipalities altogether). Geomorphologically, it is part of the Posavje hills, a pre-Alpine area traversed by the Sava River and its tributaries.

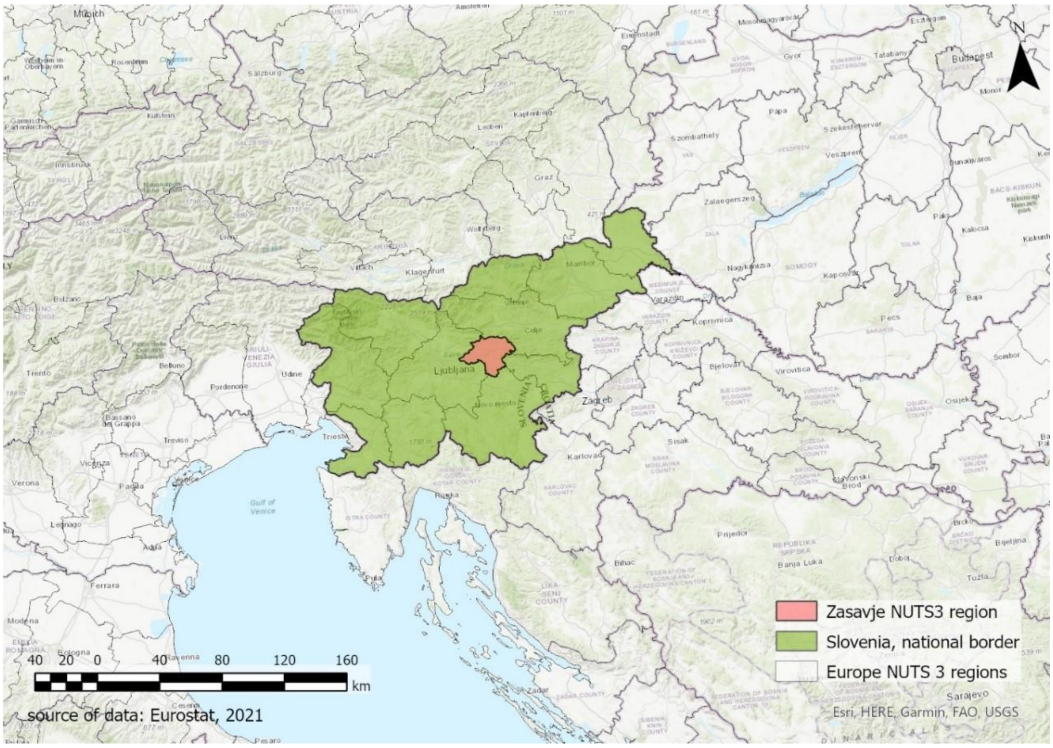


Figure 11-1:Location of the Zasavje, Slovania

Source: Eurostat, 2021

The landscape of the region is characterized by steep hills and mountains, forests, and small, scattered agricultural fields. Forest is the predominant land use (67.5%) and occurs in all higher and steeper parts of the region. This is followed by grassland (21.0%), which is found in the flatter and lower areas. Built-up areas (5%) are found along watercourses in the bottoms of narrow valleys. Agricultural land is extremely rare due to the lack of larger flat areas and is widely scattered in the form of small arable fields (1.5%) and orchards (2.1%). Refer Table 11-1 for additional regional information.

The region can be classified as a post-industrial region, or more specifically, a post-mining region. The mining started in 1755 with the discovery of brown coal in Zagorje ob Savi, and 50 years later, in 1805, in Trbovlje as well. At the beginning of the 20th century, the Zasavje region was among the most developed areas of Slovenia; the mine was bringing prosperity and amenities for the population (hospitals, schools, etc.). The brown coal mines were crucial economic development drivers up until 1995, when the first closure process started at Zagorje ob Savi's mine. In the period from 1988 to 2014, the number of employees in the mines went from 3.820 to only 178 (Marot, 2012, after Ivančič Lebar, 2004; Černe and Leskovar, 2009). It took the region approximately 20 years to reset, and now the prevailing sector, according to the regional gross added value, are services (retail, health, real property business). Industry still contributes to 31.7% of the gross added value; agriculture plays a rather marginal role with only 3.3% (Regional Development Programme, 2021).

Table 11-1:Regional Information Zasavje, Slovania

Dominant land use:	Forest (67.5%)
Secondary land use:	Grassland (21.0%)
Climatic Zone:	Cfb, Temperate oceanic climate, without dry season and warm summer (Temperate continental, central Slovenia)
Soil WRB classification:	Cambisols and Leptosols
Soil type:	Cambisols: Eutric, Dytric or Chromic . Leptosols: Mollic, Rendzic or Dystric
Dominant topsoil texture:	Different Loamy textures (loam, silt loam)
Soil threat(s):	1. Soil erosion, 2. Soil contamination, 3. Soil acidification, 4. Urban sprawl and urbanization & 5. Invasive organisms
Policy Strategy:	On municipal level: municipal spatial plans with land use zoning; no policy on national level
Representative regions:	Post-mining region, Central European region

11.2Stakeholder Interaciton

A workshop on soil quality and soil management in Zasavje region took place on May 17th 2023. It took place at the premises of the Regional Development Agency Zasavje and was attended by about 15 participants representing various organisations, including three out of four municipalities in Zasavje (mostly representatives of planning departments), public institutions, e.g. Chamber of Agriculture and Forestry of Slovenia, private actors and companies (Figure 11-2). It was a productive and informative event that brought together individuals with different skills and experience in the field of soil and soil management. The workshop was divided into three parts addressing key aspects related to soils and soil management.

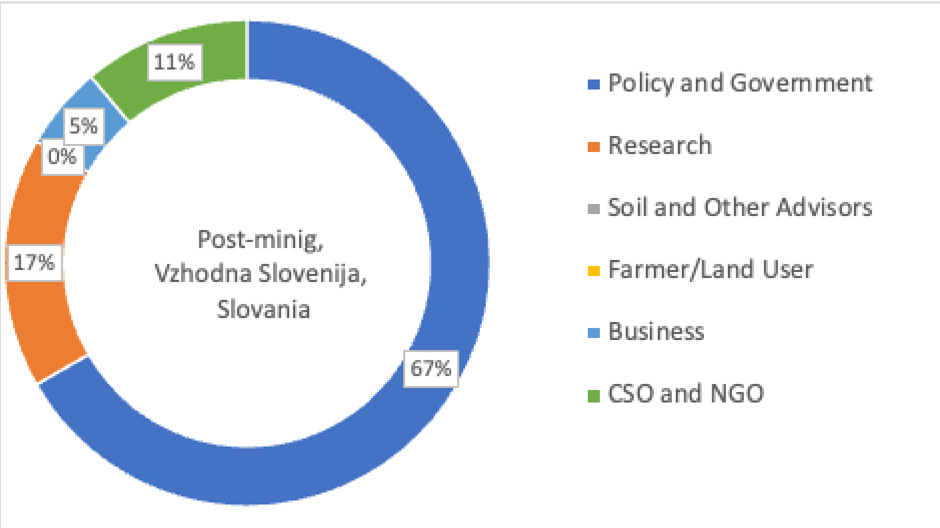


Figure 11-2:Stakeholder interaction in Vzhodna Slovenija, Slovenia

11.3Soil Needs Assessment

11.3.1Drivers

Biophysical drivers: The most important biophysical elements that significantly influence the soil in the region under study are the **parent material and topography** (which determines all the important properties, including thickness, i.e., depth, pH value, nutrient supply, buffer capacity to neutralize pollutants, slope, etc.), **water** (together with relief, water action determines soil thickness, erosion processes on slopes, and has created floodplains in valleys by filling, where agricultural production is possible), and **vegetation cover,** which protects the soils from (too) strong erosion processes.

Parent material and topography: The varied rock structure of the area means that the surface is highly dissected. Due to the different rock compositions and the high proportion of impermeable and less weathering-resistant rocks, the surface of the region is highly dissected and has numerous gullies and valleys. Slope processes are still active reshapers of the environment and can be observed on a larger scale during natural disasters (landslides). The average altitude of the study area is 532 m, which is close to the national average (557 m). The predominant slope is between 20° and 30° (34.5%). These areas are usually forested, as they have deep gorges and narrow river valleys unsuitable for building. Only 16.5% of the area is below 10° and can be found in the narrow valley bottoms.

Water: The Sava is the main river that crosses the area for a length of 47.3 km. Most of the tributaries of the Sava in the area of the rugged Posavje hills are classified as torrential. The most dangerous of them are the Medija and the Boben. They rise during storms, pour over narrow, flat areas, and tear up the banks. Regulation of the torrents mainly took place (and still takes place) in the valley areas, where streams were channeled and floodplains were cleared to make room for urban sprawl. The valley sections of the Medija, Kotredeščica, Trboveljščica, and Boben torrents were regulated, but only locally and unsystematically. Erosion processes and the destructive power of water bodies will continue to be very negative factors as soil-degrading elements in the region. With the expected climate changes (expectation of a higher number of thunderstorms), the torrential character of watercourses will intensify. In the past, the Sava was classified in the worst quality class, but after the rehabilitation of industrial plants and coal mines in the region, the situation has improved considerably. Previously, heavy metals, hydrocarbons, phenolic compounds, and mineral oils were present in the river.

Vegetation cover: The area is 67.5% forested, which is above average for Slovenia. In addition, former man-made grassland areas have been intensively vegetated over the last 100 years. The importance of the vegetation cover is reflected in the fact that 8.3% of the region, or 12.4% of all forests, are classified as protective forests, which means they cannot be cleared due to the strong erosion potential. Forests have been severely damaged in the past (air pollution, soil acidification), but their health has improved and is expected to further improve in the future, as most negative trends have been stopped or at least significantly slowed down. The region's forests will therefore protect the soils (especially from soil erosion) better than they did in the past.

Socioeconomic drivers: Both in the interviews and in the workshop, it was emphasized numerous times that national and local politics (or their lack thereof) are important drivers that impact soil quality and management. For now, the only documents guiding soil management are the national law on agricultural land (restrictions to build on such land) and the local municipal plan defining the strategic objectives and the zoning of the land.

The mining activity in the past and the accompanying industry have been recognized as the most relevant socio-economic driver in the region to impact the soil and its quality. Due to the sediments of the heavy metals in the soil, this influence will remain, despite the fact that the source may not be active anymore. For the future, we foresee that the influence of mining activities on socio-economic development will lessen and that in 30 years, the region will establish itself as a fully service-oriented society.

11.3.2Pressures

Of all the known negative processes, the following are the most pronounced in the region: **Soil erosion** and other negative slope processes (landslides). The region has a high hazard potential from negative slope processes. This means that the natural conditions themselves (which are not directly influenced by humans) are such that erosion and landslides are constantly present. These include high, even extreme, slopes, abundant rainfall, rocks susceptible to slope processes, and shallow soils. On the positive side, however, most of the entire region is unsuitable or poorly suited for anthropogenic land use, and forests remain relatively well protected. The greatest pressure therefore comes from activities that potentially reduce forest cover on steep slopes:

- Reckless and unprofessional clearing of forests for timber production.
- Damage to forest vegetation through pollution (the decline of conifers due to sulfur compounds and acid rain as a result of electricity production at the Trbovlje thermal power plant (TPP)).
- Damage to vegetation from surface and underground mining (quarries, mining-induced ground subsidence).
- Construction of roads and buildings on steep and unstable slopes leads to changes in groundwater flows, stresses and strains in rocks and soils, and, of course, re-vegetation of the area.
- Soil and water contamination

The region is affected by past, long-term, regular, or occasional excessive pollution, old environmental pressures, and degradation of landscape-forming components (water, air, soil, vegetation, relief) in most of the side valleys and nearby uplands due to coal mining, energy, industry, urbanization, and road traffic. Environmental pollution from air emissions, sewage, and various wastes, as well as land degradation from coal mining, exceeds the very limited self-purification capacity of the environment in many areas. As a result, excessive concentrations of heavy metals in soils, plants, and wildlife tissues occur repeatedly. The excessive pollution of the watercourses (the Sava and especially the left tributaries), the long-standing inadequate treatment of municipal and industrial wastewater, the inadequate regulation, and the torrential character of occasional floods have also led to the accumulation of toxic substances in the watercourses over the years, especially in the floodplains. The soils in the wider area continue to be polluted by dust and soot particles as well as heavy metals due to emissions from the air (thermal power plant, cement factory, incinerator). Contamination is rather diffuse and fairly evenly distributed across the entire region.

Soil acidification: Past acid exhausts and depositions from the Trbovlje TPP led to severe air pollution and therefore soil acidification, which reduced soil fertility and affected plant growth, especially in coniferous forests of silver fir (*Abies alba*) and Norway spruce (*Picea abies*). The construction of the tall chimney has virtually eliminated the emission pressure in the vicinity of the Trbovlje TPP on the region's ecosystem, but it has increased it in the region around Kum hill and the wider regional and interregional environment.

Urban sprawl and industrialization: As is typical for Slovenia as a whole, the pressure on the flatter and shallower soils in the region under consideration is markedly strong. Given the very limited possibilities for human activities (settlement, industry, and infrastructure), most of the land in the habitable area that is most suitable for cultivation has long been used up.

Underground mining and surface extraction of rock material in individual quarries have also had a negative impact on soils. In the first case, it is soil subsidence or spoil heaps; in the second case, it is a wound in the surface left without a protective soil layer. Therefore, as the region continues to develop, the pressure on the flatter parts of the region will increase, and there is a risk that it will be completely overbuilt.

Invasive organisms: Alien invasive species, especially plant species, can proliferate or colonize vacant, degraded, abandoned, bypassed, and other disturbed areas. These significantly alter natural and semi-natural habitats, their environmental characteristics, and water and soil conditions. In terms of nutrient and organic matter uptake, nutrient and water withdrawal, and other aspects, they also have a negative impact on the soil.

11.3.3State

Biophysical situation*:* The region is characterized by a marked duality, reflected in virtually all biophysical elements, which play a key role in the state of the environment and thus of the soil. The duality in the region is most evident between:

- the mountainous part: higher altitudes, steep and rugged topography, hard and consolidated rocks, rapid runoff from watercourses, area above the temperature inversion zone, better weathering, shallow soils, above-average forest cover, predominant indirect environmental and soil impacts;

- the valley part: low elevations, flat topography, softer and unconsolidated rocks, inflow of water from uplands, area below the temperature inversion zone, poorly weathered, thicker soils, above-average anthropogenic use.

The state of soils in the entire region is, on the one hand, a direct reflection of natural factors (parent substrate, surface, climate, water, time, and also vegetation cover). On the other hand, soils, especially in the valleys, are a reflection of human activities. In most other parts of the valley, the soils are completely transformed. Urban uses (green spaces, parks) predominate, where the soil is covered with semi-permeable or impermeable materials and layers (asphalt, concrete, sand, mining, energy production, and industrial production residues).

When it comes to the state of the region's soils, pollution is the most important, especially in the lower valley parts, near the industrialized areas. The region is generally considered to be more polluted than the rest of Slovenia. Studies of soil pollution show excessive contamination of soils with dust particles, heavy metals, including cadmium, mercury, chromium, etc., and long-standing soil contamination with sulfur compounds (Lobnik, Verščaj & Zupan, 1993; Repe, 2002). Soils have suffered particularly severe chemical damage from exposure to acidic sulfur compounds. The pH has dropped by an average of one pH level (and more in some places), first in the immediate vicinity of the TPP and then in the wider region.

The situation of slope processes is also worth mentioning. The entire upland area is potentially highly vulnerable to water erosion and landslides. Fortunately, the vegetation cover is good and stabilizes the soil relatively well. However, areas with softer, poorly adhering rock are already inherently extremely vulnerable to landslides. Stakeholders have identified climate change as one of the biggest challenges in the future, especially the torrential showers, storms, and heavy rain and their impact because of the unfavorable terrain and soil type, and mostly because no adaptation or mitigation policies have been put in place. The region is struggling with landslides and recuperating from already present damage, and this will only be magnified in the future.

Finally, human encroachment into this space is problematic. This is especially true for the construction of roads and various buildings, subsidence due to mining, abandoned quarries, and unprofessional forest clearance (clear-cutting). The consequences of slope processes are visible in the whole region through frequently closed roads and endangered buildings.

Socioeconomic situation: Past mining activity as well as on-going industry and energy production were identified as the main drivers impacting the soil quality. In the past, a calculation was done that estimated that around 4 meters of soil (in depth) should be removed in order to establish again what the state of the healthy soil was (Lobnik, Verščaj &

Zupan, 1993). There is currently a lack of financial resources, which causes a barrier to both the monitoring of soil health and the implementation of soil health improvement measures.

Another barrier is policymaking at the national level, as there is currently no national strategic document concerning only soil. Mostly, regulation concerning the soil is related to the agricultural land and spatial planning legislation (and limitations of its use), but no separate regulation exists for soil sealing or similar. Additionally, politics and politicians were identified as problematic factors due to their lack of affinity for soil and land use. Politics, especially on the local level, are mostly investment-oriented and have not shifted towards more sustainable practices.

11.3.4Impacts

The steep and rugged topography makes the soil less stable and shallow, and, in combination with heavy rainfall, the soil is subject to landslides. On the other hand, the parent rock, which is predominantly acidic, makes the soil of suboptimal quality for cultivation. Soil quality in the valley and along watercourses in the region has been severely affected by development and industry, which has resulted in the loss of the more fertile areas of the region, while mining in the area over the past decades has left areas of degraded soils due to opencast mining and tailings disposal. Poorly managed riparian watercourses also negatively affect the soil through bank erosion and stockpiling of material.

The region has a high hazard potential from negative slope processes such as water erosion, landslides, high slopes, and the silicious matrix. Activities such as reckless and unprofessional clearing of forests, pollution, and other industrial plants have caused negative impacts on the region, such as erosion and landslides, accumulating heavy metals, and soil sealing. Temperatures are expected to increase, leading to increased potential for disease development and pest proliferation. Construction of roads and buildings on steep and unstable slopes leads to changes in groundwater flows, stresses, and strains in rocks and soils, posing a permanent and real threat to transport routes, industrial and residential buildings, and the already scarce fertile land.

The region is mainly affected by past and long-term regular or occasional excessive pollution, old environmental pressures, degradation of landscape-forming components due to coal mining, energy, industry, urbanization, and road traffic, resulting in excessive concentrations of heavy metals in soils, plants, and wildlife tissues, as well as watercourses. The excessive pollution of the Sava River, especially the left tributaries, the long-standing inadequate treatment of municipal and industrial wastewater, and the torrential character of the river with occasional floods have led to the accumulation of toxic substances. Further, the soil in the wider area continues to be polluted by dust and soot particles, as well as with slightly elevated levels of heavy metals due to emissions from the air.

Soils have suffered severe damage from exposure to acidic sulfur compounds, with the pH value dropping by an average of one pH level. This has had a significant negative impact on vegetation, and a gradual improvement is expected in the future. Underground mining and surface extraction of rock material have also had a negative impact, with soil subsidence or spoil heaps and a wound in the surface left without a protective soil layer. The return to the natural, original state can be facilitated by humans, but it involves high costs and constant monitoring of the overgrowth process. Alien invasive species can proliferate or colonize vacant, degraded, abandoned, bypassed, and other disturbed or ruderal areas, causing both ecological and economic damage.

Climate change will have a negative impact on forest cover. Temperatures are expected to increase, causing maladaptation of beech and conifers to higher temperatures and increased potential for disease development and pest proliferation, e.g., bark beetles (*Scolytinae*). All this will have a significant negative impact on the vegetation cover. As a consequence, forests could no longer effectively perform the functions of hillslope soil retention and soil formation.

11.3.5 Response

The response is the result of the interviews and the workshop, performed in May 2023. In the future vision of soil management, the stakeholders mostly see the establishment of monitoring of the quality of the soil, performed on a yearly basis. For this purpose, the existing regional lab called the Regional Technological Center could take over the role of implementing this analysis and also communicate the results to the people of the region. Multiple stakeholders have mentioned there should be an information center with information available on how to react in case polluted soil is detected; this information should be provided by knowledge carriers like academia and research institutions, mostly situated outside of the region.

Regarding the policy sector, it was pointed out that adequate soil legislation should be adopted at the EU level, but that municipalities should also manage space strategically and through multi-year programs, where the focus should be on ensuring soil quality. In the area of construction, guidelines should be revised to include the possibility of green roofs and the use of natural materials.

The knowledge of municipal officials in soil management should also be improved, and activities such as soil treatment in school gardens should be included in education as part of the core subjects. Even in kindergartens, children can learn about what soil is and what can be produced from it through raised beds, orchards, or other learning polygons.

The suggestion was made that the construction of shopping centers, which occupy large areas of Zasavje's towns, should be limited. Further, a certain proportion of degraded land could be brought back into use through appropriate rehabilitation and revitalization. The heavily polluted soil that remains from the past will, however, remain a challenge since replacing this volume of soil is impossible and other ways of mitigation are not efficient enough yet.

In the field of agriculture, a number of measures have been highlighted, such as new crops in the fields instead of maize, hemp, and sorghum, which are good soil cleaners; the reintroduction of small livestock, goats, and sheep for better soils and lifestyles; the sharing of machinery, especially tractors and cooperatives; community composting plants, etc. It is necessary to establish allotment areas with clear conditions for cultivation, which must, for example, be free of plant protection products. Urban forests and orchards could also be established with a forest management plan and professional maintenance.

As a transport measure, the construction of a cycle path was highlighted as a contribution to reducing soil pollution. More efficient collection and disposal of waste and reduction of packaging could also contribute to soil quality, as this would prevent wild landfills.

11.4Conclusions

On the basis of the report and workshop findings, we would suggest the following research:

- Multi-year monitoring of the quality of soil (fertility, heavy metals, etc.) in selected regions.
- Photo documentary of the poor soil (degraded soil) areas and good practices to raise awareness and better illustrate to the stakeholders how to manage soil in a good manner.
- Pilot actions of good soil management practices (transformation of practices from other similar regions, pilot testing and evaluation).
- Online platform as a pilot activity to present road maps of how to proceed in case poor soil quality is identified (the platform should be user-friendly and targeted towards the general population).
- Establishment of the lighthouses and good practice examples.
- Analysis of the governance framework for soil management and preparation of guidelines on what policies we need and who should be in charge (clearly define the obligations and roles of stakeholders on different administrative levels).

- Citizen science: raise awareness of the importance of soil and the knowledge of the population for sustainable management of soil.

11.5 References

ARSO. 2005. „Klimatografija Slovenije, Povprečna višina padavin, obdobje 1961-1990“. Ljubljana, Slovenia: Agencija Republike Slovenije za okolje. http://www.arso.gov.si/vreme/poročila in projekti/državna služba/Povprecna_skupna_visina_padavin_v_obdobju_1961-1990.pdf.

ARSO. 2006. Podnebne razmere v Sloveniji (obdobje 1971-2000). Ljubljana, Slovenia: Agencija Republike Slovenije za okolje. http://meteo.arso.gov.si/uploads/probase/www/climate/text/sl/publications/podnebne_razmere_v_sloveniji_71_00.pdf.

ARSO. 2009. „Tla“. Poročilo o stanju okolja 2009, 17. http://www.arso.gov.si/varstvo okolja/poročila/poročila o stanju okolja v Sloveniji/tla.pdf.

ARSO. 2014. „Atlas okolja [Environmental Atlas]“. Agrencija Republike Slovenije - Atlas okolja [Slovenian Environment Agency [Environment Atlas]. 2014. http://gis.arso.gov.si/atlasokolja/profile.aspx?id=Atlas_Okolja_AXL@Arso.

ARSO. b. d. „Spatial data distribution for INSPIRE directive“. Spatial data distribution for INSPIRE directive. Ljubljana, Slovenia: Agencija Republike Slovenije za okolje. http://gis.arso.gov.si/wfs_web/faces/WFSLayersList.jspx.

Belec, Borut., Jerneja. Fridl, Matej. Gabrovec, Mauro. Hrvatin, Božidar. Kert, Drago Kladnik, Franc. Lovrenčak, idr. 1998. Slovenija: pokrajine in ljudje. Uredil Milan Orožen Adamič in Drago Perko. Ljubljana: Mladinska knjiga, Ljubljana.

Blumlein, Petra, Bettina Schug, Isabel Wieshofer, Sigbert Huber, Marco Parolin, Mattia Biasioli, Peter Medved, idr. 2012. Tla v mestu. Startegija upravljanja z urbanimi tlemi [Urban Soil Management Strategy]. Let. 2012.03. Celje / Ljubljana: Mestna občina Celje / Kmetijski inštitut Slovenije.

Commission, European, Institute for Environment and Sustainability (European Commission. Joint Research Centre), European Soil Bureau, in European Communities. 2005. Soil atlas of Europe. Luxembourg: European Communities.

Čuden, Ivo. 2009. „Klasifikacija gozdnih tal na apnencu v skladu s slovensko in WRB klasifikacijo [Classification of forest soils on limestone according to the Slovenian and WRB classification]". Ljubljana, Slovenia.

Gosar, Mateja, in Robert Šajn. 2005. „Arsenic in the environment enrichments in the Slovenian soils". Geologija 48 (2).

Grčman, Helena, Nataša J Vidic, Marko Zipan, Franc Lobnik, Arwyn Jones, in Luca Montanarella. 2015. „Tla Slovenije s Pedološko Karto v Merilu 1:250000 = Soils of Slovenia with Soil Map 1:250000 (Book, 2015) [WorldCat.Org]". Http://Soil.Bf.Uni-Lj.Si/Projekti/Pdf/Atlas_final_2015_reduced.Pdf. 2015. http://soil.bf.uni-lj.si/projekti/pdf/atlas_final_2015_reduced.pdf.

GURS. 2006. „Digitalni model višin 5 m (DEM5) [Digital elevation model 5 m]". Ljubljana: Geodetska uprava Republike Slovenije [The Surveying and Mapping Authority of the Republic of SloveniaGeodetical Survey]. http://www.gu.gov.si/.

Kralj, Tomaž, in Helena Grčman. 2009. „Harmonizacija klasifikacije z WRB". Uredil Borut Vrščaj. Poročila CRP projekta V2 051 DKT-TIS. Ljubljana: Kmetijski inštitut Slovenije.

Lobnik, Franc, Nataša Vidic, Helena Grčman, Anka Lisec, Marjan Šporar, Marko Zupan, Tomaž Prus, idr. 2006. „Tla Slovenije - pedološka karta v merilu 1:250.000 [Soils of Slovenia: Soil map 1:250.000]". Novi izzivi v poljedelstvu 2006 [New challenges in field crop production 2006] I: 193–97.

Lobnik, Franc, Borut Vrščaj, in Marko Zupan. 1993. „Podatki tal in talni informacijski sistem (TIS) : onesnaženost tal v Sloveniji/Soil data and Soil nformation System (SIS): Soil Contamination in Slovenia". V Kakovost vode z vidika uporabnosti za namakanje kmetijskih zemljišč, Portorož, 27. - 28. septembra 1993, 1993:1–15. Zavod za tehnično izobraževanje Ljubljana: Ministrstvo za kmetijstvo in gozdarstvo.

Marot, N. 2012. Zasavje (Slovenia)–A region reinventing itself. In: Wirth, P., Černič Mali, B., Fischer, W., (eds.) P*ost-mining regions in central europe-problems, potentials, possibilities*, OEKOM, Muenich. Pp. 104-117.

MKO. 2014. „Raba kmetijskih zemljišč Republike Slovenije 1:5.000 [Land use digital database (1:5.000)]". Raba. Ljubljana: Ministrstvo za kmetijstvo in okolje [Minstry for Agriculture and the Environment]. http://rkg.gov.si/GERK/.

Ogrin, Darko. 1996. „Climatic Types in Slovenia". Geographical Bulletin 68 (1–2): 39–56. http://www.dlib.si/details/URN:NBN:SI:DOC-NDDCHX2Y.

Ogrin, Darko, in Dušan Plut. 2009. Aplikativna fizična geografija Slovenije. 1. natis. Ljubljana: Znanstvena založba Filozofske fakultet.

Prus, Tomaž, Tomaž Kralj, Borut Vrščaj, Marko Zupan, in Helena Grčman. 2015. Slovenska klasifikacija tal. Ljubljana: University of Ljubljana, Biotechnical Faculty CPVO in Kmetijski inštitus Slovenije. http://www.mop.gov.si/fileadmin/mop.gov.si/pageuploads/zakonodaja/varstvo_okolja/tla/Slovenska_klasifikacija_tal.pdf.

Prus, Tomaž, Franc Lobnik, in Borut Vrščaj. 1985. „Pedološke raziskave agromelioracijskega območja Povšnik - Seruč pri Litiji / Soil investigations in Povšnik - Seruč near Litija amelioration area". Raziskovalna poročila CPVO. Ljubljana, Slovenija: Univerza Edvarda Kardelja v Ljubljani, Biotehniška fakulteta, VTOZD za agronomijo / University of Ljubljana, Biotechnical Faculty, Agronomy Department.

Regionalni razvojni program Zasavske regije. 2021. URL: https://www.rra-zasavje.si/si/regionalni-razvoj/regionalni-razvojni-program-zasavske-regije-2021-2027/ (quoted May 2023)

Repe, B. 2007. „Natural vegetation in Slovenia". Geografija v Soli 16 (3).

Repe, Blaž. 2002. „Soil Degradation Threat to Slovenia's Landscapes = Ogroženost Slovenskih Pokrajin Zaradi Degradacije Prsti". Geografski Zbornik, št. 42: 99–121.

Repe, Blaž. 2004a. „Soils of Slovenia". V Slovenia: A Geographical Overview, uredil Milan Orožen Adamič, 51–56. Ljubljana, Slovenia: Association of the Geographical Societies of Slovenia, Založba ZRC.

Repe, Blaž. 2004b. „Vegetation of Slovenia". V Slovenia: a geographical overview, uredil Milan Orožen Adamič, 57–62. Association of the Geographical Societies of Slovenia; Založba ZRC.

Repe, Blaž. 2006. „Svetovna klasifikacija prsti". Geografski Obzornik.

Repe, Blaž. 2007. „Naravna vegetacija Slovenije". Geografija v šoli 16 (3): 21–28.

Repe, Blaž. 2008. „Ugotavljanje razprostranjenosti tipov prsti v pokrajini z uporabo klasifikacijskih metod daljinskega zaznavanja". V Geografski informacijski sistemi V Sloveniji 2007–2008, uredil Drago Perko, Matija Zorn, Nika Razpotnik, Marjan Čeh, David Hladnik, Marko Krevs, Tomaž Podobnikar, Blaž Repe, in Radoš Šumrada, 195–206. Založba ZRC. https://books.google.si/books?id=pVC0HfXSVMQC.

Repe, Blaž. 2009. „Pedogenetske in morfometrične opredelitve krajinsko-talnih enot (KTE) Slovenije". Ljubljana, Slovenia.

Repe, Blaž. 2010. „Recognition of the Slovenian soil classification types“. Dela 34. https://doi.org/10.4312/dela.34.8.143-166.

Repe, Blaž. 2018a. Mednarodni klasifikacijski sistem za poimenovanje tal in izdelavo legend na zemljevidih tal 2014 (posodobitev 2015). 1. izd. Ljubljana ;Rim: Znanstvena založba Filozofske fakultete ; Rim : Food and Agriculture Organization of the United Nations. http://www.fao.org/3/I3794SL/i3794sl.pdf.

Repe, Blaž. 2018b. „Soils in the Slovenian educational system“. Bulletin of Geography. Physical Geography Series 14: 99–108. https://doi.org/10.2478/bgeo-2018-0010.

SURSa, 2023. Arrivals and overnight stays of tourists by YEAR, MUNICIPALITIES, COUNTRY and MEASURES URL: https://pxweb.stat.si/SiStatData/pxweb/en/Data/-/2164526S.px/table/tableViewLayout2/ (quotation May 2023)

SURSb. 2023. Measures of the activity (%), by statistical regions, Slovenia, annually. URL: https://pxweb.stat.si/SiStatData/pxweb/en/Data/-/0762115S.px/ (quotation May 2023)

Świtoniak, M., C. Kabała, A. Karklins, P. Charzyński, P. Hulisz, Ł. Mendyk, A. Michalski, idr. 2018. Guidelines for Soil Description and Classification: Central and Eastern European Student's Version. Uredil Marcin Świtoniak, Cezary Kabała, Przemysław Charzyński, in Aldis Karklins. Toruń: Polish Society for Soil Science.

Špes, Metka, Dejan Cigale, Barbara Lampič, Karel Natek, Dušan Plut, Aleš Smrekar, in Metka Špes. 2002. Študija ranljivosti okolja: metodologija in aplikacija. Geographica Slovenica. Ljubljana: Slovenska akademija znanosti in umetnosti, Založba ZRC.

Konferenca ob svetovnem dnevu tal, Matej. Knapič, Tomaž Kralj, Ana. Vovk Korže, Blaž. Repe, Franc. Lovrenčak, Pedološko društvo Slovenije., in Ministrstvo za okolje in prostor. 2007. Strategija varovanja tal v Sloveniji: zbornik referatov Konference ob svetovnem dnevu tal 5. decembra 2007. Ljubljana: Pedološko društvo Slovenije.

Vidic, Nataša J., Tomaž. Prus, Helena. Grčman, Marko Zupan, Anka. Lisec, Tomaž Kralj, Borut. Vrščaj, idr. 2015. Tla Slovenije s pedološko karto v merilu 1:250000 = Soils of Slovenia with soil map 1:250000. Luxembourg: Evropska komisija, Skupni raziskovalni center (JRC). https://www.worldcat.org/title/tla-slovenije-s-pedoloko-karto-v-merilu-1250000-soils-of-slovenia-with-soil-map-1250000/oclc/938656240.

Vrščaj, Borut. 2007. „Pregledna pedološka karta Slovenije. [Generalised soil map of Slovenia 1:1M]“. Ljubljana: Kmetijski inštitut Slovenije [Agricultural Institute of Slovenia].

Vrščaj, Borut, Helena Grčman, Tomaž Kralj, in Tomaž Prus. 2019. „Klasifikacija tal Slovenija 2019: sistem za opisovanje in poimenovanje tal Slovenije (delovno gradivo)“. Ljubljana, Slovenia.

Vrščaj, Borut, in Franc Lobnik. 1997. „Digitalni podatki tal Slovenije“. /, 16.

Vrščaj, Borut, in Tomaž Prus. 1998. „European Soil Database (scale 1:1.000.000) - SLOVENIA“. Ispra, Italy: Joint Research Centre.

Vrščaj, Borut, Blaž Repe, in Primož Simončič. 2017. The soils of Slovenia. Dordrecht: Springer. https://www.worldcat.org/title/soils-of-slovenia/oclc/989490239.

Vrščaj, Borut, in Irena Tič. 1998. „Digitalni podatki tal Slovenije. Gradivo kot pomoč pri uporabi digitalnih pedoloških podatkov. Verzija 1.0“. Ljubljana: Univerza v Ljubljani, Oddelek za agronomijo, Center za pedologijo in varstvo okolja.

Vrščaj, Borut, Marko Zupan, in Franc Lobnik. 1989. „Računalniška obdelava podatkov v projektu tematska karta onesnaženosti zemljišč Celjske občine“. Zbornik Biotehniške fakultete Univerze v Ljubljani 1989 (13): 41–58.

12 Dense Urbanism: Noord Amsterdam, The Netherlands

Laura Nougues (laura.nougues@deltares.nl), Linda Maring (linda.maring@deltares.nl)

12.1Regional Information

In the urban area of Amsterdam (Figure 12-1), there are major issues in the built environment in which the soil and subsurface play a role: land subsidence affecting buildings and infrastructure, parks, and rural areas around the city; lack of space (above and below the surface); contaminated and degraded soils (a.o. by compaction and sealing); poorly functioning green areas; and an increase in flooding due to limited water storage capacity in combination with climate change, which also causes increasing drought and heat stress. Amsterdam has great ambitions that come together in the Environment and Planning Strategy (*Omgevingsvisie (Gemeente Amsterdam, 2021))* and require a healthy, well-managed soil-water system. Where the policy focus is often only on the environmental (chemical) quality of soils in Amsterdam, a broader, integrated approach in urban areas is needed that includes the biological and physical perspectives as well. That is why Amsterdam has the ambition to translate the soil health concept, as developed for rural areas, to urban areas (Vlaar et al., 2022). Refer Table 12-1 for additional information about the region.

Figure 12-1:Map of the Amsterdam, The Netherlands

Table 12-1:Regional Information about Amsterdam, The Netherlands

Dominant land use:	Artificial land
Secondary land use:	• Artificial built-up area - (inner city, housing no garden, offices, schools) • Artificial industrial built-up area - (industrial area, harbor…) • Artificial non built-up area (sealed) (parking lots, infrastructures, roads, rails) • Urban brownfield (=land in transition to more beneficial use) • Road and railway berms • Private gardens with green potential (office gardens, housing) • Leisure (events, sport fields, playgrounds) • Parks / urban green area / “Neighborhood greens” (“buurtgroen”) • Urban agriculture • Agricultural area outside the city • Nature and recreational areas outside the city (incl water & peatland) • Subsurface space
Climatic Zone:	Moderate maritime (or oceanic) climate
Soil WRB classification:	Gleysols and Histosols (but mainly technosols)
Soil type:	Anthroposols, peat, sea clay
Dominant topsoil texture:	NA (in many urban areas fill sand is used, in parks / gardens /etc garden soil can be applied)
Soil threat(s):	Sealing, contamination, loss of biodiversity, loss of organic matter (peat), land subsidence, soil degradation due to disturbance, compaction, and -in parts (external)- salinization (through Noordzeekanaal)
Representative regions:	Highly urbanized areas all over Europe. Especially in the same climatic regions / delta areas (soft soils).

12.2Stakeholder Interaction

A stakeholder workshop is orgniased on 20 April 2023 with various stakeholders from Amsterdam region (Figure 12-2) The objectives of the workshop are

i) Checking the results of the desk study and interviews to develop a shared understanding of the current situation regarding soil needs in the region.

ii) Gathering future visions from the participants, including key challenges and opportunities related to the vital soil.

iii) Identifying potential promising Living Labs and Lighthouses

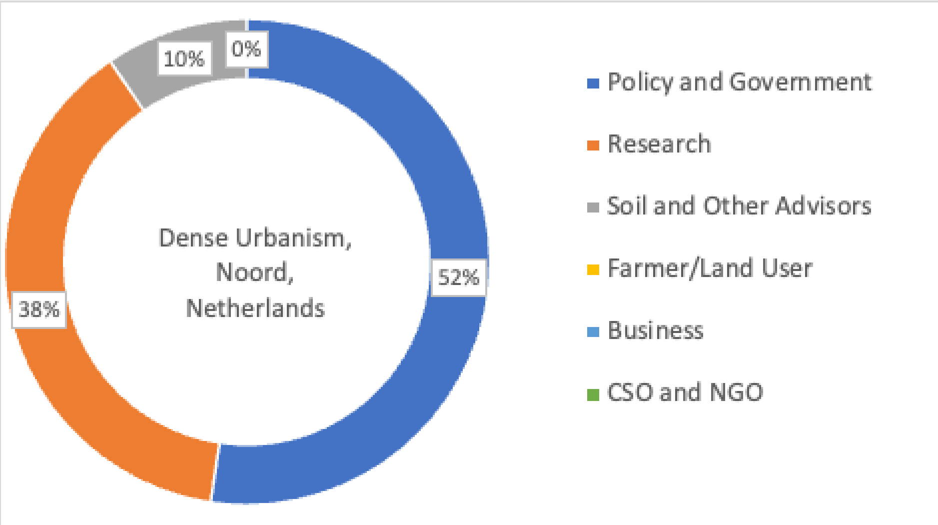


Figure 12-2:Stakeholder interaction in Noord, The Netherlands

12.3Soil Needs Assessment

12.3.1 Drivers

Biophysical drivers:

Climate change: with climate change, warmer summers and more extreme rainfall events are predicted to happen in the coming years. Projections of the Royal Netherlands Meteorological Institute (KNMI) show both average and yearly extreme temperatures increasing. The average temperature in 2050 could be 1-2.3°C higher than the 1981-2010 average, and maximum summer temperatures are also expected to increase, causing heat stress and droughts in Amsterdam. KNMI projections show that by 2050 annual mean precipitation could be 2.5-5.5% higher than during 1981-2010. The frequency and intensity of extreme precipitation events are projected to increase by 2050 (IEA, 2022).

Socioeconomic drivers:

Urbanization: Both today and in the past, Amsterdam has had a high urbanization rate due to the city's progressive industrialization and economic prosperity. The city's population is set to continue to grow, with another 150,000 inhabitants by 2035 (BiodiverCITY, Van den Berg et al., 2021). Amsterdam has set a target to build 7,500 houses per year the coming years (planning 2022-2028 is to build 73,660 houses (Gemeente Amsterdam, 2023)).

The digital and energy transition*:* By 2025 Amsterdam wants to reduce its CO_2 emission by 5%, by 2030 by 55% and by 2050 by 95% compared to the CO_2 emission of 1990 (Gemeente Amsterdam, 2022). To achieve this reduction in emission, the subsurface will be used more for installation and operation of renewable soil energy (aquifer thermal energy storage), and district heating, geothermal and aquathermal sources. In the coming years, the (further) digitalization of society will play a role in soil health. Again, more space will be needed in the already overcrowded subsurface for electricity, data and internet cables.

Greening transition*:* In Amsterdam a shared, green strategy is being elaborated, in which more individuals and organisation are working towards expanding urban green. There is more attention for nature developments like nature-friendly banks (green quay walls), nature-friendly infrastructure (green roofs and vertical gardens). Also, on a smaller, individual scale, citizen participation trends are stimulated in Amsterdam, like removing the tiles from private gardens and urban agriculture.

12.3.2Pressures

A unique feature of urban areas is that, next to their evident main residence function, there are many other, (sometimes spatially competing) land uses. It is therefore important to note that the pressures on soils are not uniform across the whole urban region but vary according to the different land uses. Refer to the Figure 12-3; Figure 12-4; Figure 12-5 for the stakeholder developed interactions.

Pressures caused by climate change: For Amsterdam this means: river discharges are higher in winter, lower in summer, causing ***water shortage*** and ***flooding***. More extreme rain events also increase flooding events. ***Longer and more extreme droughts and heat*** cause urban heat stress, damage to green areas, but also to infrastructure and intensified land subsidence. Sea level rise can increase ***external salinization*** through the North Sea Canal (Noordzeekanaal).

Land subsidence (also caused by urbanization): In Amsterdam, where there is a soft subsurface (clays and peats), water management (lowering groundwater tables to keep dry feet) and increasing constructions and infrastructure loads on the subsurface accelerate land subsidence. This issue is expected to be greater in the future with increasingly warm and dry summers, when groundwater levels drop, and with high urbanization rates, meaning extra loads applied to the soft subsurface.

Pressures caused by Urbanization Soil sealing*:* Urbanization and the construction of buildings and roads cover up soil, resulting in different forms of soil degradation and a lower water infiltration capacity in the Amsterdam soils.

Soil compaction and soil disruption weakens the healthy soil (BiodiverCity, Van den Berg et al., 2021). Building and installing new renewable resources (also linked to the energy transition) often requires the use of heavy machinery that leads to soil compaction. This is also the case with the maintenance of public spaces, which causes (more) soil compaction and sometimes also disruption to green areas.

Soil contamination: Past urbanization, industrialization and harbour activities, have led to soil contamination in the Amsterdam subsurface. Also, incidents with spills have occurred, and can currently still occur. In - most cases, these contaminations are being remediated or controlled.

Pressures caused by the Energy and digital transition Warming up of the subsurface*:* Due to the expected growth of geothermal and aquathermal energy sources, the future subsurface of Amsterdam is expected to get warmer. What warming up of the soil system means in terms of its functions, is in many cases unknown. It can affect soil life with unknown effects:

- Positive can be: more microbiological activity, increase of biodiversity, cleaning up contaminations.
- Negative can be: increase of soil-born pests and diseases, invasive species, increased heat stress.

Subsurface use of space (also caused by urbanisation): the increasing number of functions in the soil can hamper the soil's system functioning (e.g. disturbed groundwater flows) and decrease biodiversity and the potential delivery of ecosystem services. Another problem is simply the lack of available space.

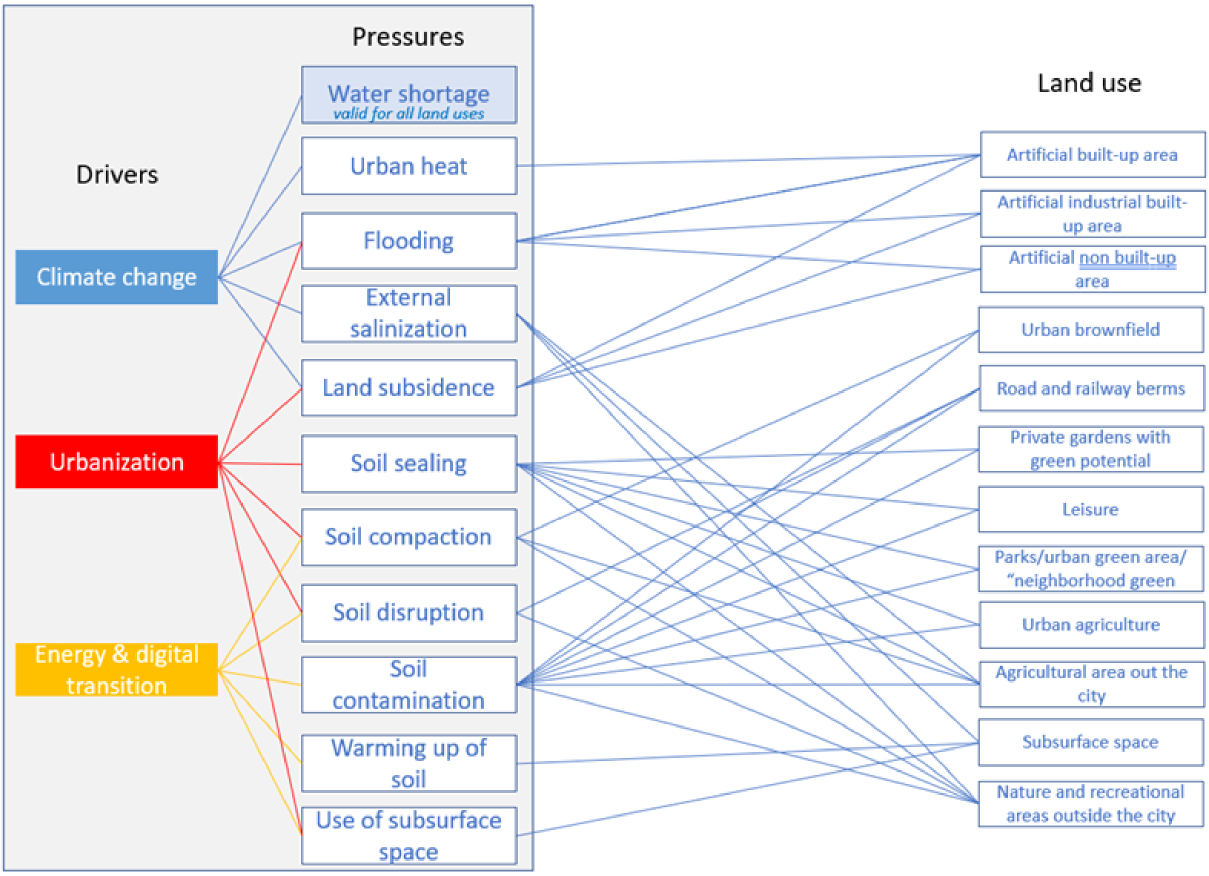


Figure 12-3:Pressures for the different urban land uses Noord, The Netherlands

12.3.3State

As explained before, in urban areas many different land uses can be identified, each with its specific soil functions and therefore its own soil health indicators. Figure 0.2 summarizes where the soil functions and proposed indicators (based on the *Raamwerk definitie gezonde bodem Amsterdam*) are linked to the land uses.

The **carrying function** is critical for *artificial built-up areas, artificial industrial built-up areas* and *artificial non built-up areas.* Here, relevant indicators are the carrying capacity and the stability of the topsoil layer. Being influenced by climate change and urbanization, the increasing land subsidence can cause damage to constructions and building foundations, especially with the soft subsurface found in Amsterdam.

As being underused land, *urban brownfields* are not directly dependent on specific soil functions, but they can however benefit greatly the **natural buffer/filter for (polluting) substances** soil function. Important to note that the soil first needs to be restored up to the desired quality for the follow-up use.

Road and railway berms have a high potential **habitat for ecology** as they cover a significant area of Amsterdam. However, the soil quality of these soils is strongly affected by the surrounding roads and railways. Roads with heavy traffic negatively affect soil quality through processes like the combustion of fuel, the wear and tear of tires and the wear of the road surface that gets flushed into the subsurface during rain events. *Parks/urban green area/"neighbourhood greens"* also provide a **habitat for ecology**. This potential is jeopardized by the fact that these terrains are being used more intensively for events. This results in a compacted soil, that can provide less ecosystem services to biodiversity.

Further, *parks/urban green area/"neighbourhood greens", private gardens* and *nature and recreational areas outside the city* play an important role for **water storage and discharge.** These functions are being negatively influenced by increasing soil sealing and soil degradation (incl. compaction). While Amsterdam has low lying parts, and because of the sealing and the limited capacity of the urban drainage system, floods are problematic.

In *leisure /sports* areas, the chemical quality of the soil is critical. Chemical quality of the urban soil in Amsterdam is, although no urgent risks appear, poor, as in most historical cities. Almost all urban areas deal with diffuse contamination (e.g. diffuse lead due to the use of lead pipes in the past) and emerging contaminants such as PFAS. This is also relevant for *private gardens with green potential* and *urban agriculture*, where citizens can come into contact with the soil, or food produced from the contaminated soil. The municipality advises against directly gardening into the soil.

Looking at the **energy potential** in Amsterdam, the build-up of the *subsurface space* is significant. The space has to be efficiently planned to make way for the implementation of new cables and structures related to the energy transition. Although subsurface cables and pipes (C&P) need to be registered since 2008, there are still many orphan C&Ps in the soil. Therefore, the subsurface is full and a lot of damage (to C&P, etc) occurs every year when performing activities in the subsurface. For the energy production potential for Aquifer thermal energy storage (ATES), the fresh – salt water interface in the soil is important as well as the conductivity of the aquifer. ATES can conflict with other groundwater uses but does not have direct impact on the phreatic groundwater in the first meters of the subsurface due to its depth. However, the constructions in the shallow soils and the potential warming of these layers can cause soil degradation, which can lead to effects on (ground)water regulation and biodiversity.

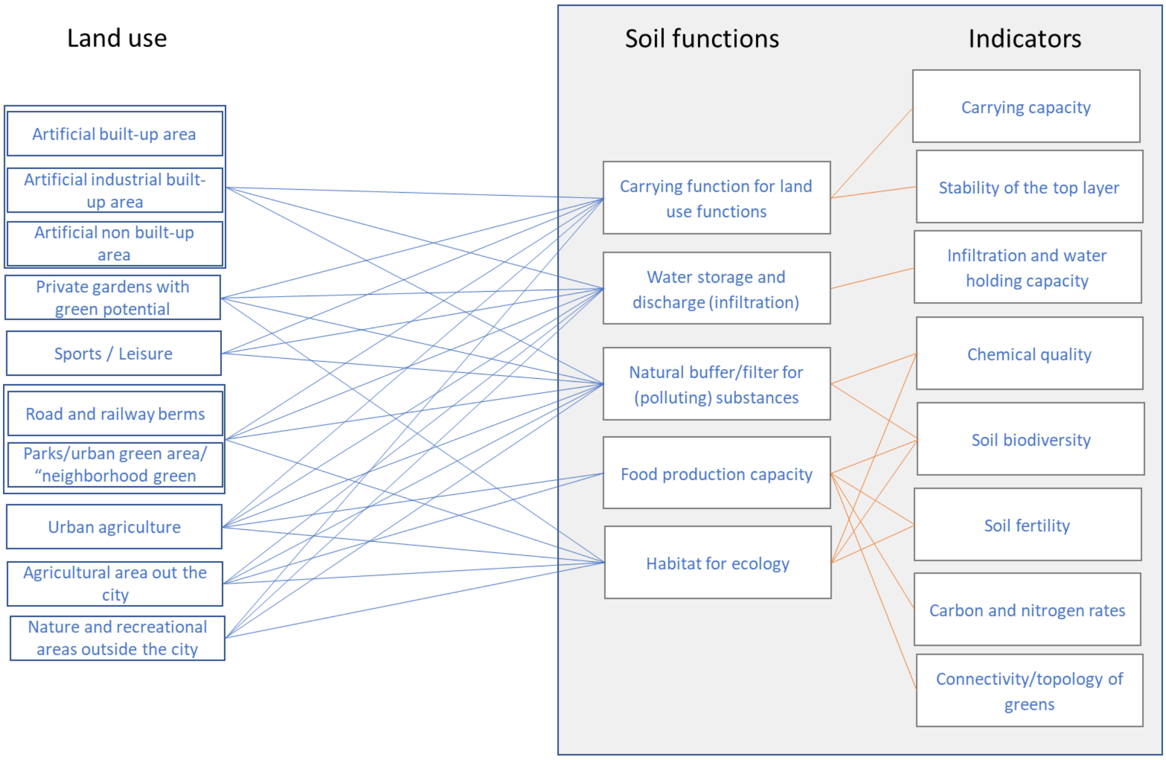


Figure 12-4:Land uses linked to soil functions and proposed indicators

Source: Derived from the “Raamwerk definitie gezonde bodem Amsterdam” (Vlaar et al., 2022)

12.3.4Impacts

Soil degradation (incl. compaction): Urbanisation, including soil sealing, excavation activities, temporary interventions and the use of heavy equipment during building or maintenance can have long-term negative effects on the soil. The soil becomes disturbed and compacted and so soil life and root growth are harmed, and water and oxygen can penetrate far less well into the soil, which has a detrimental effect on soil structure and biodiversity (BiodiverCity, 2021).

Loss of organic matter and GHG emissions: Both urbanisation (poor water management and soil sealing) and climate change (lower summer groundwater levels) cause peat mineralisation and GHG emissions. (Figure 12-4; Figure 12-5)

Decreasing (chemical) soil quality: Human activities, floods, breaking sewer pipes, industrial activity, and drug/chemical dumping/disposal, may lead to soil contamination. Due to climate change, external salinization and (groundwater and soil) quality can change because of intrusion of water with a lower quality and droughts.

Loss of habitat function, biodiversity and capacity to deliver ecosystem services: Due to the disturbed urban soil quality, plants and trees do not grow up to their full potential. Leading to a poor (soil) biodiversity and degradation of the urban ecosystems. Unhealthy soil dries out more than a healthy, vibrant soil, meaning that with an unhealthy soil, land subsidence and compaction are stimulated more (BiodiverCity, 2021). This will have a negative impact on the carrying capacity of the soil. The growth and densification of Amsterdam can lead to the destruction of green structures, and the splitting up, fragmentation or even destruction of fauna habitats in the city due to the conversion of the surrounding land (BiodiverCity, 2021). Likewise, the mowing and maintenance schedule of road and railway berms can also destroy habitats if not done in a correct way.

Damage and disturbance caused by land subsidence and climate change: The high pressure exerted on the soil due to new constructions and infrastructures (including cables and pipes for the energy and digital transition) can cause extra land subsidence and cause existing cables and pipes to break. Breaking sewer pipes can lead to soil contamination. With climate change trends leading to prolonged periods of hot and dry weather, the soil will dry out more in future summers, resulting in higher rates of soil compaction and land subsidence.

Decreasing water storage capacity: With the rapid urbanisation rate in Amsterdam, more surfaces are being sealed meaning, less rainwater can infiltrate into the subsurface, lowering groundwater levels. In the artificial built-up area, this can lead to the rotting of wooden foundations, the loss of stability and damage to infrastructure. In addition, if rainwater cannot be stored in the subsurface due to extensive sealing, all the rainwater during extreme rain events will create peak runoff situations that can cause pluvial flooding, erosion and surface water contamination. Both these effects will only be strengthened in the future with climate change, with hotter periods and more extreme rainfall events.

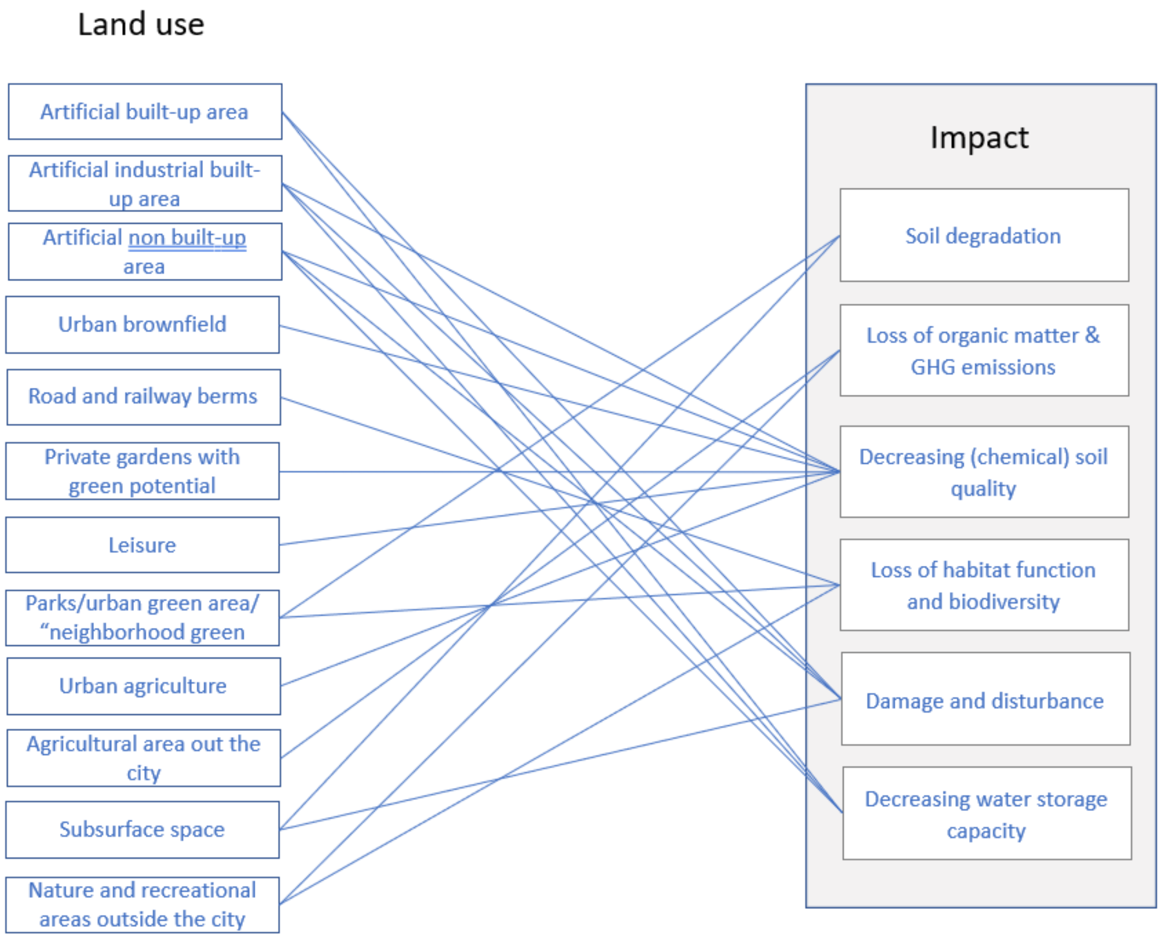


Figure 12-5:Critical impacts for the different land uses in Amsterdam

12.3.5Response

Expanding on research, knowledge & data: In terms of knowledge, the first question that must be answered is what a healthy soil is in the city. As mentioned earlier in this report, the land use is decisive in defining what a healthy soil is, as different land uses need to deliver different services. Once an urban soil health framework is defined, it is important to expand on the current urban soil health knowledge. This is being elaborated in Amsterdam using the soil health index (Vlaar et al., 2022), in which urban land uses are being linked to soil functions and indicators.

More research and knowledge are urgently needed about what lives in the soil and what their role is within the chemical/biological processes in the subsurface, and how to best monitor all these aspects. Lastly, it is important to bring together all the collected data and knowledge and make it available and accessible, preferably on a central database. This will enable (data) validation and (knowledge) exchange.

Combining multifunctional uses of space: An integral approach is needed in which synergies are recognized and land uses are combined. There must be an overarching strategy for the use of available urban space, both above the surface and in the subsurface. This can entail layered constructions in the subsurface (energy sources, sewage pipes and cables), using infrastructure (such as quay walls) for green/blue infrastructures, finding a balance between stability and water permeability of the soil, and creating more biodiversity along roadsides and in berms.

Policy: While soil health is in many cases not the top priority for policy makers, the municipality should determine what to preserve, restore, stimulate and avoid with regards to healthy soils. This has started with the *Raamwerk definitie gezonde bodem Amsterdam* (at this moment this policy is not yet administratively committed, but this is planned for the near future, as is a vision on soil health that is in development) and can be done in the instruments of the Environmental and Planning Act. Also, the regional, national and European policy is currently steering towards policies and regulations that consider soil health. Because in urban areas many, sometimes competing, interests are recognized, different policies should be checked for unfavourable trade-offs and policies should also be realistic. A "multifunctional" healthy soil will not be achievable everywhere in an urban area. It is good to define where to start.

Barrier: Currently a lot of political attention is centred on climate change and climate mitigation, but not yet on biodiversity or soil health. Chance: Soil and water as a steering element in spatial planning (Water en bodem sturend): this is a policy document which aims to ensure the sustainable use and protection of water resources and soil ecosystems, taking into account ecological, economic and societal interests. However, this policy still has many unclarities that need to be concretized on local scale.

Instruments and approaches: To optimally include soil aspects in (spatial planning) decisions, the soil assessment frameworks and spatial practice need to be adjusted. This requires several things: knowledge (link *Expanding on research, knowledge & data),* capacity, the connecting of soil issues (link *Combining multifunctional uses of space)* and getting the necessary people around the table.

Living Labs (LL) can be very valuable in closing existing urban soil health knowledge gaps. To have a successful LL, a (positive) social cost-benefit analysis is needed. On the long run, the involved parties should get more from the LL (through knowledge gained, awareness raised, money saved) than what it cost. Also, cooperation is essential for a successful LL: all relevant actors must be involved (land owners, policy makers, researchers, citizens, etc.) and a sense of ownership must be created.

Raising soil awareness & responsibility: A social transition is needed in which we are more aware of the value of the natural soil system in urban areas. For this transition, a new management approach is needed. It should be stimulating for citizens to change their behaviour and allow room (i.e. financial aid) for local initiatives supporting the mindset of "the next big thing is many small things". Citizens and governments should also work better together. Soil should be seen as both a *common* as well as an *asset*, in which soils are recognized as a valuable asset, which must be maintained. Also, a sense of responsibility and ownership should be stimulated within not only policy makers, but also within citizens and private landowners.

Barrier: Culture change. How do you change behaviour / mindsets?

Concrete measures to improve soil health:

Not removing natural litter: natural waste such as dead invertebrates, leaves and wood provide a good habitat for soil life.

- Minimize digging: digging should be done with light equipment and on the smallest possible scale to minimize soil compaction.
- Unsealing surfaces.
- Implement ecological mowing practices (i.e. phased mowing).
- Reintroduce native plants and trees.

12.4Conclusions

The literature study, stakeholder interviews and workshop has highlighted several key points that contribute to understanding and improving urban soil health. Defining what constitutes healthy soil with respect to the different land uses within the urban area is crucial. It is important to recognize the unique characteristics and requirements of urban soils which differ from the more homogenous agriculture, nature and forest soil ecosystems. Both spatial planning (where to do what) and spatial design (how to do it) are instruments to optimize soil health and ecosystem delivery, by relating the land use better to the natural system. This requires some kind of asset management of soils in urban areas. Further, an integrated approach is necessary for the use of space. This means implementing more multifunctional areas. Synergies and trade-offs between land uses and ecosystem services should be considered in decision-making. This is not common practice yet, but with the Integral Design Method for Public Space Amsterdam, a step forward is being taken.

Next to soil health, another issue relating to soils in urban areas, which is different from other land uses, is the use of subsoil space. Urban areas use the top layer for C&Ps and different building activities (parking garages, tunnels, waste containers etc.) and the deeper subsurface for geothermal energy and drinking water supply. Subsoil planning is therefore an important activity that has not developed yet and is not institutionalized nor sufficiently set in regulation and policy.

While research plays a large role in broadening our knowledge on urban soil health, it is equally important to move beyond pure research and take concrete actions. Currently, there is a great deal of attention for soils in the Netherlands (and in Europe), which provides a favourable momentum for implementing changes.

An important issue in urban areas is the ownership of the land. Next to public areas, there are multiple landowners (citizens, businesses, NGOs etc) that own a large share of urban land in Amsterdam. This means that steering towards soil health encompasses all these landowners. Raising awareness on the importance of healthy soils is therefore key. This is both on a local scale (citizens and landowners) as well as on a regional/national scale (government and policy makers). By highlighting the ecological and social potential of urban soils, higher appreciation can be created. Similarly, soil health awareness can help close the gap between citizens, urban landowners and governments. Engaging citizens and urban landowners in soil-related initiatives and involving them in planning and decision-making processes creates a sense of ownership and responsibility for urban soils.

When looking at the most urgent steps that need to be taken to achieve significant gains in urban soil health in Amsterdam, the following priority list is suggested:

1. Define soil health in urban areas: important here to distinguish between land uses. This can be supported by clearly defined frameworks and policies. Amsterdam is working on this with the “soil health index” for Amsterdam on the basis of the “framework definition healthy soils (Vlaar et al.,2022)
2. Take concrete actions: it is important to implement changes quickly.
3. Raise awareness and create a shared vision: bring citizens, urban landowners and governments together and create a shared vision in which soil is seen as a valuable asset.
4. Invest in urban LLs: LLs can help broaden knowledge on the currently little-known urban soil health, but further, they can be used to raise awareness and bring different stakeholders together and therefore can play a crucial role in achieving healthy soils in Amsterdam.

12.5 References

Berg, J. van den, Gomes, S., Korthals, G., Made, H. van der, Merckx, V., Mota de Oliviera, S., Nuytinck, J., Oosterheerd, I., Rienks, F., Roos, M., Schilthuizen, M., Stech, M., Zijlmans, R., Zoest, J. van (2021). BiodiverCITY. A Matter of Vital Soil! Creating, Implementing and Upscaling Biodivercity-based Measures in Public Space. ISBN: 978-90-9036125-3. Retrieved from: https://openresearch.amsterdam/image/2022/7/1/lowlow_res_def_soil.pdf

EC (2021) A Soil Deal for Europe: 100 living labs and lighthouses to lead the transition towards healthy soils by 2030. Implementation Plan. Directorate-General for Research and Innovation, European Commission. Internal working document of the European Commission

Gemeente Amsterdam (2021). Omgevingsvisie Amsterdam 2050. Available on: https://amsterdam2050.nl/

Gemeente Amsterdam (2022). Nieuw Amsterdams Klimaat, Klimaatrapportage 2022. Retrieved from: https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/coalitieakkoord-uitvoeringsagenda/gezonde-duurzame-stad/klimaatneutraal/

Gemeente Amsterdam (2023). Woningbouwplan 2022-2028, Amsterdamse aanpak voor de nieuwbouw van woningen. Retrieved from: https://assets.amsterdam.nl/publish/pages/881646/2-woningbouwplan_2022-2028.pdf

Hommes-Slag, S., Kok, S., Rooze, D., Kluts, M., Bel, M. de (2022). Quick Scan bodemdaling in Amsterdam. Verkenning van omslagpunten leefbaarheid en economische impact in 5 pilotgebieden. Deltares.

IEA (2022). Netherlands Climate Resilience Policy Indicator. Retrieved from: https://www.iea.org/articles/netherlands-climate-resilience-policy-indicator

Vlaar, T., Veerman, L., Rouing, S., Souwer, J., Mayer, A. (2022). Raamwerk definitie gezonde bodem Amsterdam. Gemeente Amsterdam en Omgevingsdienst Noordzeekanaalgebied.

Consulted websites

Climate adaptation map Amsterdam: https://maps.amsterdam.nl/klimaatadaptatie/ [last accessed June 2023]

Example Action group “behoud Lutkemeer”: http://behoudlutkemeer.nl/ [last accessed May 2023]

Example Excavation damage: https://www.agentschaptelecom.nl/binaries/agentschap-telecom/documenten/publicaties/2021/05/31/infographic-schade-door-graafwerkzaamheden-2020/Infographic+WIBON+schade+door+graven+2020.pdf [last accessed May 2023]

Example Urban Farm: http://www.urbaniahoeve.nl/ [last accessed May 2023]

Example urban agriculture: https://tuinenvanwest.info/ [last accessed May 2023]

Integral Design Method for Public Space: https://openresearch.amsterdam/nl/page/58877/integrale-ontwerpmethode-openbare-ruimte [last accessed May 2023]

National Program Rural areas: https://www.rijksoverheid.nl/documenten/publicaties/2022/11/25/ontwikkeldocument-nationaal-programma-landelijk-gebied [last accessed May 2023]

NOVI: https://www.denationaleomgevingsvisie.nl/default.aspx [last accessed May 2023]

Omgevingsvisie (environmental and planning strategy) Noord-Holland: https://www.noord-holland.nl/Onderwerpen/Ruimtelijke_inrichting/Projecten/Omgevingswet/Omgevingsvisie [last accessed May 2023]

Omgevingswet (environmental and planning act): https://www.rijksoverheid.nl/onderwerpen/omgevingswet

Soil Strategy 2030 https://knowledge4policy.ec.europa.eu/publication/communication-com2021699-eu-soil-strategy-2030-reaping-benefits-healthy-soils-people_en [last accessed May 2023]

Water en Bodem Sturend (Soil and water as steering elements in spatial planning): https://www.rijksoverheid.nl/documenten/kamerstukken/2022/11/25/water-en-bodem-sturend [last accessed May 2023]

13 Post-Industrial: Upper Silesia, Poland

Siebielec Grzegorz, Świątek Karolina, Siebielec Sylwia, Łopatka Artur (Institute of Soil Science and Plant Cultivation – State Research Institute)

13.1Regional Information

Upper Silesia is a densely inhabited industrial region with a substantial post-mining and post-smelting character. Since medieval times, shallow deposits of zinc and lead ores with silver content have been mined in the region. In the 18th century, the intense exploitation of rich coal beds started. In the 20th century, Upper Silesia was among the largest European mining and industrial centers. Additionally, iron ores were exploited in the region. Refer Table 13-1 for the additional information.

Over 30% of the national electric power was produced in the region. Within the last two decades, the industry went through restructuration. Dozens of coal mines were closed down. Most of the zinc and lead ores mined and smelted have been decommissioned, but they left many waste deposits scattered within the region. Only some of them have been remediated. The region is a mosaic of post-industrial sites, arable lands, hobby gardens, and settlements. The agricultural land has been contaminated (with cadmium, lead, and zinc) by smelter emissions, and some metals in the soil originate from metal-rich parent rock material. Soils are rather fertile and are therefore used for crop production. Historical smelter waste deposits are subjected to water and wind erosion processes during intensive rainfall or long dry periods, respectively, affecting nearby arable land parcels. The surrounding agricultural fields are cropped with such plants as wheat, cabbage, sugar beet, corn, or potato, depending on the year. A combination of awareness-raising, alternative crop production systems, mitigation approaches, and methods limiting metal bioavailability would be needed since it is not realistic for farmers to stop crop production. The region also contains post-industrial sites as points of contamination that need remediation specific to the site. The preliminary assessment reveals the following challenges related to soil: land use change after closing coal mining and smelting; soil regeneration at post-industrial sites; finding new economic development in the area, including transitions in agriculture; and more sustainable spatial planning that takes soil status into account.

Table 13-1:Regional Information about Upper Silesia, Poland

Dominant land use:	industry
Secondary land use:	urban/arable

Climatic Zone:	IPCC - cool temperate moist
Soil WRB classification:	Cambisols, luvisols, podzols
Soil type:	Mineral, loamy soils
Dominant topsoil texture:	Silt loam, sandy loam
Soil threat(s):	contamination, sealing, land abandonment
Stakeholders:	advisors, farmers, city administration, spatial planners, environmental protection offices, NGOs, researchers
Policy Strategy:	mitigation of soil contamination, soil remediation where possible
Representative regions:	post-industrial areas in Eastern Europe

13.2 Stakeholder Interaction

The workshop on reginal soil needs took place at the Institute for Ecology of Industrial Areas (IETU) in Katowice on 23 June 2023. The workshop was led in a way to follow the DPSIR approach, a functional analysis for structuring the cause-effect relationships of environmental and natural resource management problems. The workshop was attended by experts familiar with the environmental situation, challenges and the region development needs in the Upper Silesian region Figure 13-1. The workshop took the form of an open and active discussion among participants.

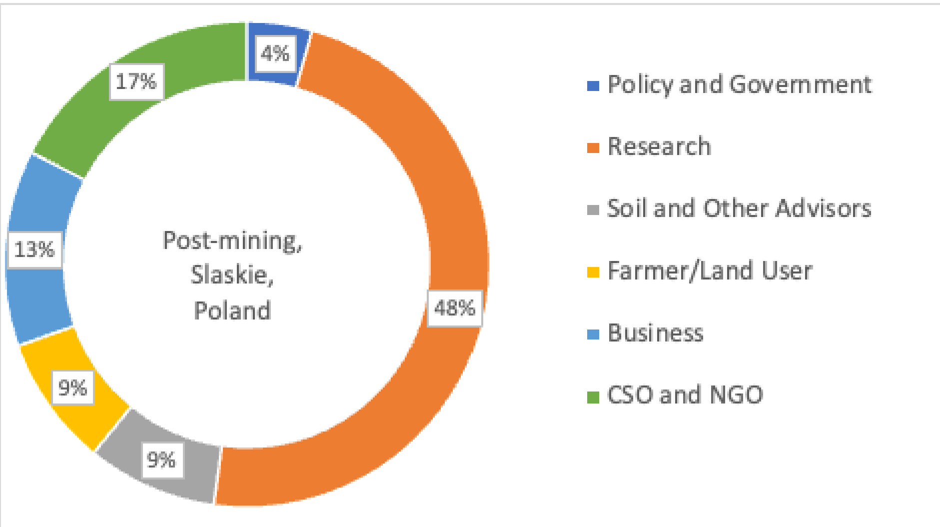


Figure 13-1:Stakeholder interaction in Slaskie, Poland

13.3 Soil Needs Assessment

13.3.1Drivers

Biophysical drivers: The major biophysical driver of soil status is soil pollution. Soils located in parts of the region with a high density of industrial sites (mines, smelters, chemical plants, and reloading stations) have been subjected to pollution processes. The exact data on a number of contaminated sites is not known, but the region contains post-industrial sites as a point type of contamination that definitely needs remediation that would have to be specific to the site. Additionally, the region is a mosaic of post-industrial sites, arable lands, hobby gardens, and settlements. The agricultural land has been contaminated in some parts of the region (with cadmium, lead, and zinc) by smelter emissions, and some metals in the soil originate from metal-rich parent rock material. This makes metals in soils less bioavailable and, in general, non-toxic to plants and soil biodiversity, but creates some problems in terms of meeting crop quality criteria. Soils are rather fertile; therefore, they are still used for crop production since high yields are in general achieved. This type of soil contamination is persistent; therefore, the contamination will persist in the future and will remain one of the major biophysical drivers in the region. This will affect the character of agriculture within the remaining agricultural land and induce the necessary changes in practice when awareness will be raised. Historical smelter waste deposits are spread within arable lands and located near human settlements and arable lands. This type of industrial legacy will remain for a long time and will require reclamation programs in order to reduce the secondary risks and give them some functions in the landscape. It is possible that the waste deposits might be used for the recovery of metals if there is such a need.

It seems that climate change is becoming a significant driver of soil status and management, both in agricultural parts and in agglomerations. As national drought monitoring reveals, the frequency of drought conditions is not the greatest in Poland; however, northern parts of the region suffer quite often. Annual precipitation in most years is in the range of 550–650 mm. Precipitation is not evenly distributed during the vegetation period. Long periods without rain induce a water shortage in the soil, which favors desertification processes. Soil degradation is accelerated by extreme rains that induce soil erosion while the excess water is not retained in the soil.

In agglomerations, high temperatures accelerated additionally by urban heat waves induce soil degradation, make soil carbon accumulation difficult, stimulate water, and especially cause wind erosion. This, in consequence, creates a risk of dust and soil particle movement into the air, which contains metal and organic contaminants.

Socioeconomic drivers: Socioeconomic drivers of soil management can be grouped into several categories: awareness, financial drivers, regulations, and social needs. Insufficient awareness of society and decision-makers is one of the major drivers. In general, there is still insufficient awareness of the ecosystem services provided by soils, especially in urban environments with larger agglomerations. The knowledge on the role of soil in creating living conditions in populated areas so far belongs to some research groups but has not been absorbed by society and bodies responsible for land management and planning at the city level. This fact means that land use change decisions in the spatial planning process in general are not taken using soil information, and the ecosystem service approach is not applied.

One of the drivers limiting the shift to more sustainable soil management in populated areas is a lack of wider discussion and the involvement of society in city spatial development. When society is not fully aware of the services provided by soil, it does not force changes in land management practices. The barriers to improved soil management, as agreed among experts, include a lack of public debate about threats in post-mining regions and those related to the coincidence of industrial sites and agriculture. There are also not sufficient information campaigns on the condition of soils or even informative soil monitoring programs.

As the driver affecting the transformation of agriculture into improved soil management, we can treat farmers' insufficient awareness of the real challenges related to soil contamination. There might be existing knowledge on mild practices that would help to avoid metal transfer to crops, but this is not transferred through an agricultural advisory to land users. The topic of elevated trace elements in arable soils is rather not raised in the discussion, except in research communications. There is also a lack of good practice examples documenting that transformation into alternative crop production might be economically viable for farmers.

Financial drivers might constitute substantial support for appropriate soil management. There are some funds available at the national and local level through national or regional funds for environmental protection for investments (NFOŚ, WFOŚ). These funds can be used for land reclamation or city transformation. Financial instruments for soil protection within agricultural lands exist in Common Agricultural Policy, for example, through eco-schemes like ‘Carbon farming and nutrient management’.

Regulatory drivers are important in steering soil management in certain directions. Concerning farmlands in post-mining regions, there is a lack of ‘executive’ regulations on farmlands that would force the transformation of regular practices. There are regulations that define when soil is treated as contaminated (threshold contents of contaminants), but there is no mechanism that would execute the rule and propose some alternatives. Lack of alternative agricultural production schemes makes the topic of elevated contaminants in arable soils a bit ‘hidden’. There is a lack of law forcing more sustainable spatial planning that would take spatial soil information and the valorization of soil ecosystem services into account. In general, municipalities are not forced to produce long-term spatial plans at the local level; therefore, many investments are admissible based on individual decisions. This is a driver of unsustainable development in the post-industrial and urban zones of this region with complicated spatial structures, even though local good-practice examples exist. The driver of short-term decisions in spatial development is the observed trend in the movement of settlements to sub-urban areas that leads to the conversion of farmland, fulfilling many ecosystem functions, into urban purposes. There are fees for the conversion of agricultural land into urban purposes set in national regulations, but such fees are rather effective in rural areas and do not pose a barrier for developers in urban and suburban zones. It is also worth mentioning the lack of interest of developers in the recovery of brownfields into new investments.

13.3.2 Pressures

The recognized drivers result in a number of pressures on soils and current soil management. Society's willingness for urbanization and movement from city centers to suburban areas created pressure on soils and accelerated land take and soil sealing. The region also needed some investments in transport infrastructure recently, especially highways omitting city centers. This resulted in the loss of biologically active areas. The existing regulations do not fully protect valuable soils, capable of fulfilling many ecosystem services, against land take. There are policy instruments establishing fees for the conversion of agricultural land into non-agricultural use. These instruments are quite effective in rural areas but apparently are non-effective in suburban zones where high investment funds are in the hands of developers. Land take causes the loss of most ecosystem services within the land taken. It is also unfortunate that rather impermeable surfaces dominate the urbanization process. Fortunately, more remote agglomeration districts are still quite accessible in green areas, and this type of land is generally well protected instead of agricultural land.

Prolonged and frequent droughts accelerate soil degradation, especially in urban zones. Insufficient soil moisture might induce a loss of soil structure, followed by wind erosion. Drought is also a limiting pressure in the regeneration processes of post-industrial soils. It lowers the biological activity of soils and plant adaptation to often difficult conditions.

Climate change and hot temperatures combined with soil sealing accelerate drying soils in urban zones, which creates a risk of soil degradation and the occurrence of heat islands.

Additional pressure on the local urban climate is related to the fact that some soils in the post-mining region have a transformed profile; therefore, they do not provide the same water retention capacity as soils with a natural soil profile.

The short-term character of green area planning results in unsustainable greening practices in cities in post-industrial regions. This pressure generates the need for integrated knowledge on relationships between plant species performance and habitat properties in soil management in post-mining and urban areas. Drought and soil erosion might accelerate contaminant dispersion in the post-mining environment with such a diverse and complicated land use structure. Soil and dust particles moved into the air carry contaminant compounds that can be inhaled by humans. Awareness of this fact is not sufficient.

Use of arable land with elevated contents of cadmium and lead creates a risk of excessive transfer of potentially toxic metals to food. It is questionable if this might affect the health of the local population since the food basket of residents is not fully local; however, it definitely affects the quality of local crops and causes problems with meeting the metal content criteria. Crops differ in their tendency to accumulate excessive amounts of potentially toxic elements. A wide range of crops are produced in a region, including cereals, potatoes, vegetables, rapeseed, and corn. Among these crops, commonly produced vegetables like carrots or cabbage create the greatest risk.

The pressures defined are driving the need for more appropriate soil management. In populated areas of post-mining regions, this refers to improved soil management in spatial planning, namely taking soil ecosystem services into account when locating land for new investments. Soil regeneration needs have been defined for post-industrial sites and some urban zones. They would have to be based on knowledge of the adaptability of plant species to habitat characteristics and the use of gentle remediation options. In agricultural areas, there is a need for practices sustaining the overall functionality of soils (soil organic carbon protection, avoiding erosion, protecting soil structure) and mitigating the risk of excessive metal transfer to food (soil liming, selection of crops).

13.3.3State

Biophysical situation: One of the major environmental problems in Upper Silesia is related to zinc and lead slag waste deposits that are scattered across a region; they coincide with urbanized zones, agricultural lands, and even hobby gardens. These deposits are generally barren of vegetation, and as a consequence, they constitute a significant source of secondary environmental pollution with metals. Some deposits are so high in metals that their contents reach up to several percent in the case of lead and zinc. This is due to inefficient smelting technologies in the past. Especially soils adjacent to waste deposits are subjected to secondary contamination through wind and water erosion. Refer to Figure 13-2 for the stakeholder assessment of soil ecosystem services.

Soils used as arable land exhibit a diversity of metal levels, from those allowing crop production without any restrictions to levels several times higher than the allowable cadmium content in the soil for agricultural production (up to 60 mg Cd/kg). The soils are fertile by nature, so they are often used for the production of demanding crops. Only some of these soils are acidic, where liming practices can help reduce the risk. In the case of soils with a regulated pH, other types of management would be needed, including the selection of crops that do not accumulate metals.

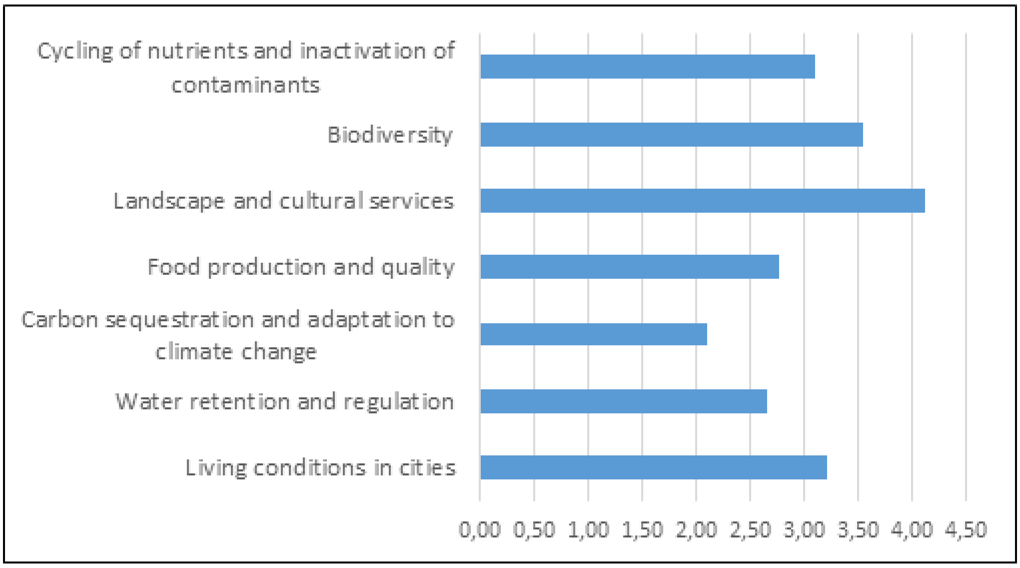


Figure 13-2:Assessment of state of soil ecosystem services by regional stakeholders

They scored the state of ecosystem services in the 1-5 range (five the greatest score – soils greatly provide the given service)

Soil erosion does not pose a significant problem on agricultural land since farmers in general apply appropriate corrective measures. This might be, however, a problem in urbanized areas where drought and loss of soil structure might induce susceptibility of soil to wind erosion. This, in consequence, induces the dispersion of contaminants into the air through the erosion of soil particles. However, there is no documented information on the scale of such processes. The risk description is rather limited to assumptions based on an understanding of the processes and relationships by scientists. Similarly, there is no structured information on soil biodiversity. Soil organic matter levels are not dramatic in comparison to other regions; they slightly exceed average SOM contents for the entire country (2.34 vs. 2.28%). This refers to agricultural land, and it must be emphasized that even average country levels cannot be treated as high in their absolute values and therefore still require special attention.

Socioeconomic situation: The weaknesses of the socioeconomic situation in relation to soil management in the post-mining region can be described as a lack of soil literacy in day-to-day land regional development and long-term spatial planning. Soil information is not used in general in spatial planning, and spatial plans are not even obligatory for municipalities. The low involvement of society in developing the future of the region and the lack of co-creation processes result in the predominance of short-term economic goals in the development of the region. There is also low integration of various domains and insufficient interdisciplinarity in regional development that would enable circular and more sustainable approaches at the city or region level.

In agriculture, there are incentives typical for any agricultural land; however, there are not sufficient incentives for the transformation of agriculture within contaminated land. Therefore, the decisions of farmers on crops are based on short-term economic pressures. Similarly, apparently there are not sufficient incentives for the regeneration of brownfields, and developers still prefer to take land from current green areas.

13.3.4 Response

There is room for improvement in the effectiveness of environmental regulations (e.g., forcing officials to adjust their decisions on land management at the city level to be more sustainable). As has been emphasized several times, urban development usually wins over environmental protection or soil protection in spatial decisions. A key response enabling improved soil management in spatial planning would be making spatial development plans obligatory for all municipalities. Raising overall awareness of the risk of cropping on contaminated soils in society would lead to pressure on food producers and providers concerning food quality. It is worth noting that there are some revitalization and remediation programs being implemented that might serve as good practice examples. This might be a good start; however, more dissemination activities and providing incentives for site regeneration are needed to make the process more common.

The future visions of experts seem to be quite realistic, and they deeply touch on the currently existing problems. They would expect more knowledge-base and interdisciplinary spatial planning in the future to protect soil functions and overall living conditions in populated areas. There is a need to raise the awareness of farmers in the Upper Silesian region about the properties of the soils and adopt agricultural production based on the soil status (e.g., energy crops instead of food crops). Common and knowledge-based use of phytoremediation for soil and air regeneration needs to be implemented. There is even a vision for developing urban agriculture using uncontaminated soils or vertical vegetable production systems. This would shorten supply chains, improve local self-sufficiency, and enable better control of food quality. The experts would also expect less marginal or abandoned land in the region to sustain the ecosystem services of soils in the future.

Among the ways to achieve such visions, the education of citizens and the dissemination of scientific research related to soil status and functions are two of the most important. Education on this subject must be systematic, which will contribute to greater awareness and involvement of citizens in regional development. Better cooperation among various stakeholders and research is much anticipated. The other measures to achieve the visions involve: establishing standards for environmental protection and soil management in spatial planning; improve ecological communication and soil literacy; make knowledge on contaminated areas more systematised and public available; implement knowledge based greening of the urban environment with species capable to adapt to conditions and to regenerate air quality; counteracting the urban heat islands by use of small greening measures such as green acupuncture, pocket parks, flower meadows, vertical gardens; developing appropriate financial mechanisms necessary for the management of problematic areas and sustaining management of regenerated sites beyond the financing projects.

There is a need for developing effective monitoring programs that would cover agricultural land and crop quality, soil sealing dynamics, soil health in urban areas, microplastic dispersion, and cycling.

13.4Conclusions

It is worth emphasizing that the Soil Mission implementation plan mentions quite a lot of measures that were highlighted by experts in relation to improving soil management in the post-mining region of Upper Silesia. Specifically, increasing soil literacy and co-creation processes involving representatives of the whole society or developing a harmonized soil monitoring program that addresses soil health and its capability to provide a wide range of ecosystem services Such measures are, however, currently not implemented at a satisfactory level. Such post-mining regions are complicated in terms of soil management challenges and needs since they constitute a combination of typical industrial, urban, and agricultural land with problems and barriers characteristic of all of these land use types.

It was agreed that the target research should focus on: concepts of green and blue urban developments in post-industrial and populated areas; effective regeneration of urban soils; cycling of contaminants in the urban system; improving knowledge on and protocols for involving society in a co-creation process; microplastic pollution and its mitigation; transformation of the main profile of agriculture in Silesia without hampering the economic situation of farmers; and developing cities as circular economy organisms with smooth integration of waste management, spatial planning, and soil management into one concept.

It was agreed that there is a relatively high potential for Soil Mission Living Labs and Lighthouses in Poland and even across urban and post-industrial regions. They could serve as good demonstration structures, for example, in terms of soil revitalization. Implementation of Living Labs would require more effort in order to establish the wide involvement of stakeholders and citizens in the co-creation processes.

The potential and need for Living Labs aimed at increasing the resilience of cities to climate change have also been recognized. This would help to lower the risk of flooding and urban heat islands by increasing water retention in populated areas. Another Living Lab idea could focus on the secondary use of industrial land in cities, which would, in the end, result in a reduced percentage of green areas being sealed. There is a great need in the region for a more systematized, updated, and available soil information database as a knowledge base. This is essential for a shift towards more sustainable soil management across the various land use types and for raising awareness across society and decision-makers.

13.5 References

Dulias R., 2016. The impact of mining on the landscape. A study of the Upper Silesian Coal Basin in Poland. Environmental Science and Engineering. Springer ISBN:978-3-319-2953-8, p. 209

Gasidło K., Wyrzykowska A. 2022. The redevelopment of the areas of liquidated coal mine sites in the Upper Silesia. Source: Post-mining areas in strategic documents of Górnośląska-Zagłębiowska Metropolis cities, Builder 12 (305). pp. 40-43, DOI: 0.5604/01.3001.0016.0927

Grabiński J., Stuczyński T. 2004. Pobieranie kadmu przez odmiany pszenicy ozimej i jarej w zależności od formy chemicznej nawozu potasowego. Ann. UMCS, Sec. E, 59: 553-55

Grabowski D., Sikorska-Maykowska M., Strzelecki R. 2005. Environmental evaluation for regional planning and management: the Upper Silesia case study. Polish Geological Institute Special Papers, 17: 28–33

Stuczyński T., Siebielec G., Daniels W., McCarty G., Chaney R. 2007. Biological aspects of metal waste reclamation with biosolids. J. Environ. Qual. 36, 1154-1162

Grzegorz Siebielec, Institute of Soil Science and Plant Cultivation – State Research Institute, gs@iung.pulawy.pl

14 Forest Peatland Northeast: Soomaa, Estonia

Anna-Helena Purre (Elige OÜ), Sabine Jordan (Swedish University of Agricultural Sciences)

14.1Regional Information

The Soomaa project area (Figure 14-1 and Table 14-1) is situated in Estonia and covers about 1060 km2, about half of which is nature protection area. The Soomaa area is characterized by low population density and wild landscapes. The dominant land uses in the area are pristine bogs, forestry on peatlands, and management of semi-natural meadows for nature protection (haymaking and grazing). A significant part of the income for the local population comes from tourism. There are almost regularly occurring annual spring floodings in Soomaa, which can cover up to 175 km2 (so-called “fifth season”).

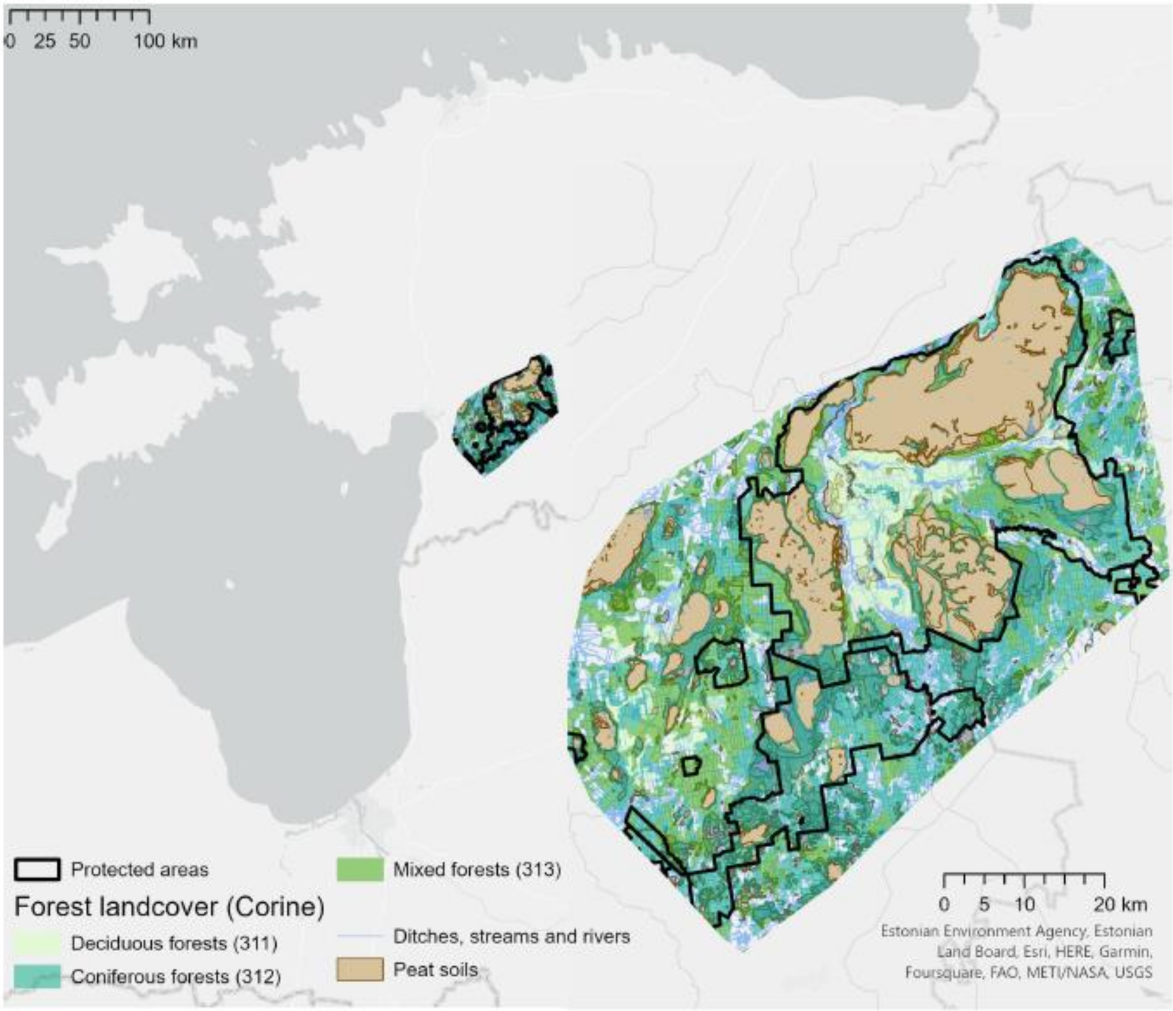


Figure 14-1:Soomaa, Estonia (small colored patch in the map), including protected areas, peat soils, forests, and drainage networks.

About 80% of the Soomaa NP consists of peat soils—bogs, fens, meadows on peaty or peat soils, and peatland forests. Peatland and forest ecosystems are one of the protection goals for both large, protected areas, Soomaa NP and Kikepera. In the surrounding areas of the nature protection objects, there are no strong restrictions for forestry, whereas various restrictions are applied in different parts of the protected areas. To improve the state of protected ecosystems, large-scale restoration of peatlands and meadows has been conducted, and the first forest restoration activities are planned in two locations.

The main soil pressures in the area are drainage impacts (increasing peat decomposition, subsidence, and carbon emissions), the impact of heavy machinery, e.g., during forest management or restoration works causing tracks and soil compaction, and trampling and erosion related to tourism. Although generally the soil health inside the NP has been considered by the stakeholders to be good, different activities have some impacts on the soils, and these impacts are often unknown. There have not been any soil-specific studies in the Soomaa area, and soils have been mainly considered as an additional explanatory parameter in the studies if the soil parameters are considered at all.

Table 14-1:Regional Information Soomaa, Estonia

Dominant land use:	Forestry on fens and transitional peatlands, and on the edges of the bogs
Secondary land use:	Nature protection (bog area with pools, forest habitats, semi-natural meadows, and birds)
Climatic Zone:	Temperate
Soil WRB classification:	Mainly Histosols: bogs in natural state but also heavily drained fen peat and transitional peat
Soil type:	Histosols, Gleysols, Fluvisols, Histic gleysols, Gleyic albeluvisols
Dominant topsoil texture:	Highly decomposed peat
Soil threat(s):	Peatland drainage for forestry; tracks from harvesters
Representative regions:	Forestry on peat soils mainly in Scandinavia and Baltic states (Northern Europe).

14.2Stakeholder Interaction

The stakeholders can be divided into public, private and community sector stakeholders. In the interview study, eight representatives were interviewed and eight were present in the workshop (partly overlapping in workshops and interviews; in addition to two organisers). Several stakeholders considered themselves to belonging to several stakeholder groups (e.g. working in state organisation or tourism operator, but at the same time being part of the local community).

In March and April 2023, eight interviews with relevant stakeholders were conducted virtually to understand stakeholders views and experience in the region and with soil-related issues in the area, and to understand the factors affecting the soil management. More stakeholders were approached for interviews, but no response was received, or people were not able to give the interviews due to busy working period during the spring (forest planting and preparations) or the sensitivity of forestry issues in Estonian society. The Soil Needs Workshop was held in the Visitor Centre of Soomaa NP on 3 May, 2023. Eight stakeholders were present in the workshop in addition to two organisers. A total of 24 stakeholders and organisations were invited (Figure 14-2). The workshop aimed at verifying the study results and gaining more insights about the soils, the status of the soils and their use of the area, gather stakeholders visions of the future, and their barriers and opportunities and identify possible development of Living Labs and Lighthouses. A large map of Soomaa on the wall of the visitor centre was a very constructive gathering point. Such a free-form approach supported the interactions between the participants and thus active discussions.

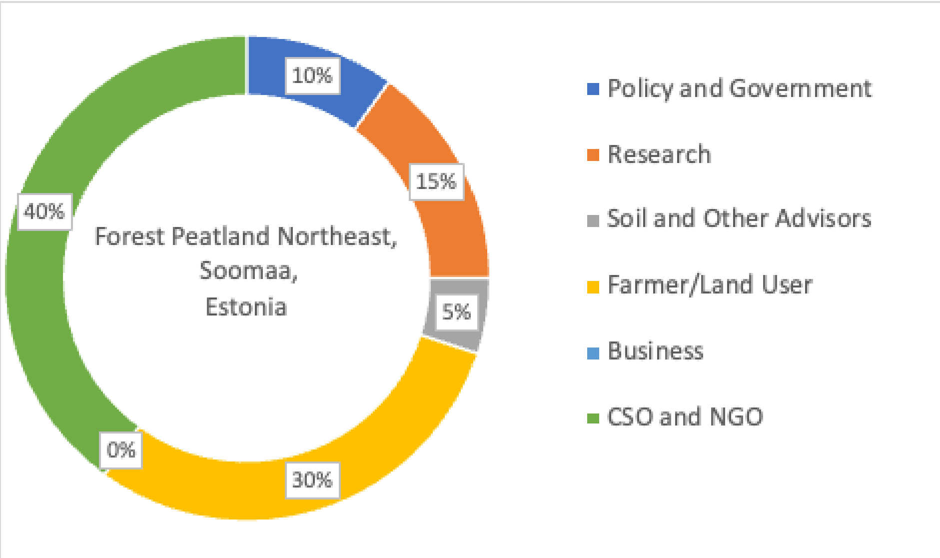


Figure 14-2:Stakeholder interaction in Soomaa, Estonia

14.3Soil Needs Assessment

14.3.1Drivers

Biophysical driver(s): The main biophysical driver in the region has been the **periodic spring flooding** related to snowmelt, the so-called "fifth season". The most extensive flood in human memory was in 1931, which covered an area of 175 km2 and was the largest in Estonia. Floods are frequent in the lower reaches of the Navesti, Halliste, Raudna, and Lemmjõgi rivers since drainage is hindered. This flooding also affects the soil's nutrient balance. Soils in forest site types that were influenced by floods over a longer period showed remarkably greater temporal variation of N, P, and C content than most forest soils less affected by the flooding in the Soomaa area, especially higher P contents were measured (Karu et al. 2004). The impact of flooding on the nutrient status of the area was also emphasized by one of the local stakeholders during the workshop. According to his description, coarser material is left near the riverbeds, creating more oxygen-rich soils, whereas finer sedimentary material is left in a thin layer all over the flooded area. The flooding affects the suitability of different tree species and restricts forest management.

During the interviews, it was mentioned by two respondents that in addition to the spring flooding, **winter flooding, or the "sixth season,"** has occurred due to warmer winters in recent years. These kinds of changes are also expected in the future due to climate change. The melted water often cannot be drained during winter due to frozen soil and therefore creates large ice fields in the forest and meadow areas when the temperature is decreasing again. The milder winters are expected to become more common due to climate change. In the further distance, it could also result in winters without snow or sub-zero temperatures, which could result in no flooding, ending the characteristic "fifth season" of the area and the newer occurrence, "sixth season".

With a changing climate, **warmer summers and extreme drought periods** are expected in the area, which has been brought up by two interviewees and was also mentioned as one of the biophysical drivers during the workshop. They concluded that this is also affecting the availability of water for forest growth during the summertime, as there is enough water available in the soil and drainage systems during the springtime after the floods. The drought has also had an impact on water availability in drinking wells and in pristine peatland ecosystems (heating of bog pools, increase in decomposition of peat). Although farmers already complain about the droughts, foresters do not, as the responses in forests are slower compared to agricultural fields with annual crops. Anyway, for forestry, it was mentioned that the drought impact is more severe for the newly planted forest during the first summer

Socioeconomic driver/issue: There have been two large socioeconomic drivers in Estonia and in Soomaa area in the past, that have their effect also in the current situation in the Soomaa area. Firstly, the **Soviet occupation after World War II** and the creation of the sovkhozes (state farms), and secondly, the **end of the Soviet period and the creation of Soomaa National Park in the 1990s**. These kinds of large-scale changes are hopefully not happening again in the future. The creation of sovkhozes ended the small farm era in the Soomaa area. During the Soviet period, mainly during 1960–1970, large-scale drainage of peat soils for forestry purposes and planting of spruce monocultures were done. During the same time, the no longer managed semi-natural meadows started to overgrow with bushes, so the forest in Soomaa is mainly secondary forest resulting from peatland drainage and lack of management of semi-natural meadows during Soviet time (in the interview study 3/8; 2 presenters in the workshop). During the period of 1959–1970, the average number of residents in villages dropped by more than 60% (Järv et al., 2016). After the end of the Soviet period, although the Soomaa NP was created quite soon, there was still a lack of management and economic activities in the 1990s in the area due to the very low population, strict protection regime, and low availability of funds (2/8 interview respondents). With EU support, there has been an increase in the restoration and management of the semi-natural meadows and peatlands in the NP, and changes are happening due to the protection regime of the NP (5/8 interviewees, 5 participants in the workshop). It could be expected that with the application of EU policies, the restoration and management of semi-natural habitats, forests, and peatlands will continue and develop in the surrounding areas of the NP in the future.

Two interviewees commented on the current intensity of forest management, which is not intense inside the NP due to the active work of environmental NGOs and nature protection restrictions, but that the clearcutting and management pressure in the bordering areas just outside of the NP is very strong. During the workshop, one representative of the local community mentioned that it is hard for the local community and private forest owners living inside the NP to take our firewood as their land is mainly in the target protection zone, where forest management is fully prohibited. They can only take their firewood from the trees falling on access roads, although they can watch their forest from their homes. This lack of income from local land could also be one cause of the decreasing population in the area. If there are no significant changes in the Protection Plan of the NP, support systems for local communities, or regional policies, the decline of the local community will continue in the future.

14.3.2 State

The soil health assessments from the stakeholders varied **from bad** (2 respondents of the interview study) **to good or very good** (6/8 respondents in the interview study). Two respondents also brought up the fact that soil health is highly dependent on the exact location, and one considered the soils inside the NP to be in a good state, whereas the soils outside of the NP are in a bad state.

Problem statement for the biophysical situation: The main problem about the soil biophysical situation was the **drainage of peat soils** in the Soomaa area for forestry purposes; this was brought up by almost all interviewed persons (7/8) and stakeholders during the workshop (6 stakeholders). The large-scale drainage network was built in the Soomaa area during Soviet times. One interviewed local stakeholder mentioned that the drainage systems inside the NP are slowly overgrown by vegetation. This negatively affects forest growth but is good for the environment. Drainage affects the soil moisture and water availability for trees and understory vegetation but also increases soil organic matter decomposition, subsidence, and loss of peat soils. Currently, there is no good data about these issues in Estonia.

During the interviews and the workshop, several stakeholders described the **unsuitable wet and soft soil conditions for forest harvesting and management** with machinery in the Soomaa area, but the tracks and related problems were generally considered to have secondary importance in comparison with the drainage impact.

Problem statement for the socioeconomic situation: The main socio-economic impact on soil management in the Soomaa area is the **decreasing population** and the **strict nature protection rules**, which create less pressure on soils and their management for forestry use. In addition, many locals are working in the tourism sector, and for them, the nice aesthetics of the forest ecosystems are important from a monetary point of view.

The key consideration that was brought up during the interviews (5/8) was the **use of EU money for reconstruction of the drainage ditches** to improve forest growth just outside of the NP, and within several meters inside the NP, large-scale peatland rewetting work has been done with EU money. It was stated during the workshop that public money should not be used for harmful practices, in this case the reconstruction of drainage networks. During the interviews, many stakeholders pointed out the need for comprehensive planning to avoid such contrasting activities close by. Due to different reasons, forest ecosystems in the Soomaa area are mainly in an average or poor state.

14.3.3Response

One local stakeholder summarized the main issues in the Soomaa area as “Soomaa is divided between three municipalities, so there is not much feeling of Soomaa and unified actions. The Environmental Board must make decisions based on legislation, which is not always most nature-friendly; old active people disappear and there are not many young and active people coming, the Soomaa cooperation network has not worked out very good and tourism people are directing the development."

The main visions of the stakeholders for the next twenty years about the Soomaa area were:

- **wilderness area** (3/8): one stakeholder considered the decrease in population as a positive; respondents wished for less infrastructure (1/8) or more location-specific infrastructure (1/8); they also brought up that there should be areas where people are not allowed at all;
- **balanced development** considering different stakeholders and economic uses of the landscapes (3/8);
- **homogenous development**, not so affected by different counties and municipalities (1/8).
- **Forestry management for the own use of farmers and a stricter approach to forest management** (3/8), clear-cutting and drainage system reconstructions should be prohibited in the NP area (1/8), and some areas should be managed for human well-being (e.g., picking berries and mushrooms, recreation, 1/8);
- **More natural succession** and restoration/management only where really needed (3/8), more long-term thinking and less project-based actions (1/8);
- **Improvement of tourism infrastructure** (2/8), especially related to rivers to avoid riverbank erosion and tramping related to tourism, also more garbage bins and boardwalks;
- **Need to increase the area of NP** (2/8), especially related to the EU Nature Protection and Nature Restoration Laws;
- **Less drastic differences** between the NP and bordering areas (2/8).

To reach those visions, the stakeholders considered that there is a need for long-term strategic planning (1/8), balanced development and consensus with and within local communities (1/8), comprehensive vision (1/8), site-specific and flexible approach (1/8), more thought through management and restoration of habitats (e.g., no need to make large infrastructure to manage a very small meadow; 3/8), less drainage system reconstruction (1/8), tourists should stay on existing infrastructure, not wandering around (1/8), and more training and schooling for land managers so they understand and have a personal connection with the land, not just mowing, grazing, and tree-harvesting (1/8). One stakeholder stated that "nature" should also be protected from nature protection and that a lot of work is done just to spend EU money.

The main barriers were considered to be the application of existing regulations to local conditions (3/8), work and views of different specialists in the state differ, as well as interpretation of the laws (2/8), need of long-term plans instead of short-term plans (1/8), counteracting demands from EU e.g. peatland restoration vs drainage reconstructions (5/8), well developed capitalism (incl. lobby and a too small country [everybody knows everybody]), and not yet developed civil society (3/8), low tourism income and not many tax payers in the area, so no motivation for infrastructure development (1/8), the state and its organisations/specialists are far away from Soomaa (1/8), problems with developments by State Forest Management (1/8), too much nature protection and restoration from EU, or stricter application of this in Estonia than elsewhere (2/8).

One stakeholder concluded, "People mainly understand now what happens with the forest biodiversity and why it is important to protect forests, but the soil biodiversity and health is not topic at all and people do not think and know about that."

Soomaa is a specific area with distinguishable features (low population density, regular flooding). Although the Soomaa area has been highly managed, and with a new protection plan, two forest restoration plots are also planned, these actions and their results are mainly not monitored and have in-depth analyses. In addition, the tourism in Soomaa has an impact on the ecosystems where it takes place; the impact of the tourism has not been studied in detail so far.

Several stakeholders have pointed out in the interviews and in the workshop that soil health and its aspects have not gained attention in the studies in Soomaa so far. It has been brought up in the interviews and the workshop that the following aspects should be studied and approached in the future:

- Research about the impacts of restoration activities, including possible negative impacts (e.g., machinery tracks, tree harvesting, flooding; 2/8);
- Tourism (incl. ecotourism) impacts soils, ecosystems, and local people (2/8);
- Balancing of nature protection and forestry management (Figure 8), including reducing the forestry environmental impact on deeply drained peat soils and optimizing timber production and climate benefits (2/8);
- Impacts of machinery working on wet peat soils in forests and peatlands, and ways to mitigate those impacts; also practical studies about forest management on peat soils (3/8);
- Studies about the flooding regime and impacts on ecosystems and people in Soomaa (2/8);
- Studies about forest fertilization outside of the protected areas to increase forest production and reduce forestry pressure in protected areas (1/8).

During the workshops and interviews, two stakeholders pointed out that the problem is not the lack of information but the need to apply the long-known basic experiences to real-life actions and everyday decisions. During the workshop, it was mentioned that in the studies, experiments, and changes of practices, the local community should also be engaged if possible and results introduced to them so they can be informed about the work and results and possibly apply those. Due to the low population density and the presence of land managers and tourism operators, Soomaa could possibly be the living lab and lighthouse for the land-use changes and land management experiments approaching the aforementioned subjects. This would also benefit the declining population in the area and the nature protection goals

14.4References

Järv, H., Kliimask, J., Ward, R., Sepp, K. 2016. Socioeconomic impacts of protection status on residents of national parks. European Countryside, 2, 67-85. DOI: 10.1515/euco-2016-0006

Karu, M., Metsmägin, M., Roosaluste, E., Lõhmus, K., Mander, Ü. 2004. Variation of plant cover and soil nutrient content in two floodplain forests in Soomaa National Park, Estonia. Pages 47-58. In (eds. J. F. Martin-Duque, C. A. Brebbia, A. E. Godfrey & J. R. Diaz de Teran) Geo-Environment. WIT Press.

Keskkonnaagentuur. 2020. ELME projekti kaardikihid. https://kaur.maps.arcgis.com/apps/MapSeries/index.html?appid=9db1c0379be24a13a94c5ad6e4829320# (used 15.07.2023).

Contact information (Email): anna.helena.purre@elige.ee and sabine.jordan@slu.se

15 Forest North: Upper Norrland, Sweden

Sabine Jordan (Swedish University of Agricultural Sciences, SLU; sabine.jordan@slu.se)

15.1 Regional Information

Roughly two-thirds (28,1 Mio ha) of Sweden's land area is covered by forests (SCB 2019), of which 3,3 Mio ha of the total forested land is on organic soils (Lindahl & Lundblad 2021). According to the FAO (2020), forest land means land within a continuous area of more than 0.5 hectares where the trees have a height of more than five meters, a crown density of more than ten percent, or where the trees have the potential to reach this height and crown closure without production-enhancing measures. Forest land is divided into productive and unproductive forest land (Figure 15-1), with the highest share of productive forests in southern Sweden and the largest forest areas in northern Sweden.

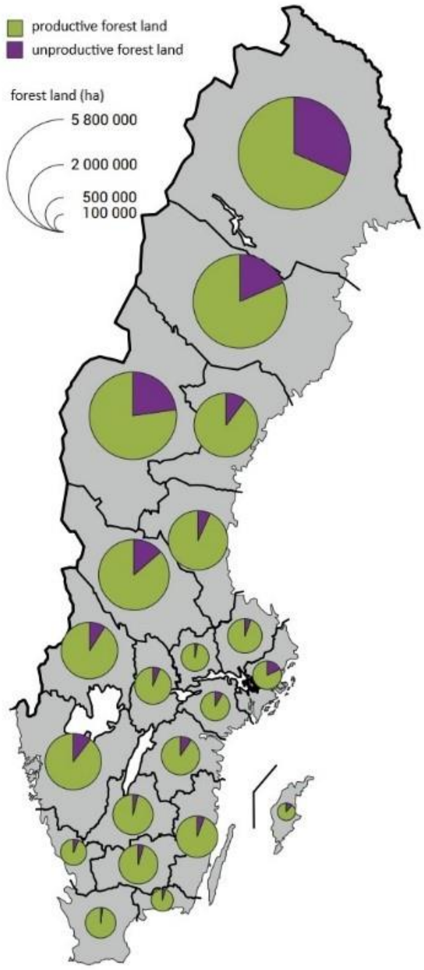


Figure 15-1:Distribution of productive and unproductive forest land in Sweden.

Productive forest land is an area that can produce an average of at least one cubic meter of wood per hectare per year. This includes, for example, certain peatlands and mountainous and rocky land that is forested. Unproductive forest land refers to forest land that is not productive forest land (Statistics Sweden 2019). Sweden as a high-latitude country encompasses boreal, hemiboreal, and temperate biomes, where young and meager soils (podzols, histosols, and chaotic deposited morainic material) and a cold climate with a short vegetation season set natural boundaries to any other land use than forestry, especially in the north. Here, historically and today, comprehensive forestry was and is hardly in concurrence with, e.g., agriculture on the same land area. Being the world's third largest exporter of pulp, paper, and sawn timber (SFIF 2018), forestry makes a significant contribution to Sweden's gross national product through a positive economy in rural areas and trade with other countries, as well as holding significant importance in Sweden's landscape and cultural heritage and traditions (Björheden 2019).

Maintaining a high net forest production while at the same time increasing or keeping the carbon sequestration potential in mineral forest soils, avoiding carbon emissions from drained organic forest soils, minimizing compaction, and promoting continuous cover forestry are key issues for Swedish sustainable forest management. Climate change is a serious concern for forestry management in Sweden. It is unclear if the change will be directed to, e.g., warmer temperatures (coupled with longer vegetation periods) and longer periods of droughts, colder winters with continuous snow cover or bare frosts, or extreme weather events that are difficult for prognosis. However, climate change and environmental forest policy adaptations in an over 1500 km-long country like Sweden must be aligned differently in the many biogeographical regions (Gustafsson et al. 2014). The first Forestry Act of 1903 already regulated the protection and management of forests in Sweden. It introduced a compulsory regeneration after clear-cutting and marked the beginning of a soft regulation tradition of forestry in Sweden, which still largely prevails under the so-called ''freedom with responsibility'' (Hasselquist et al. 2020). As a typical boreal forest catchment, the Krycklan Catchment Study has been chosen as a representative case of a managed boreal landscape. Pressures within the area on soil health are mainly related to climate change (Figure 15-2) and forest management.

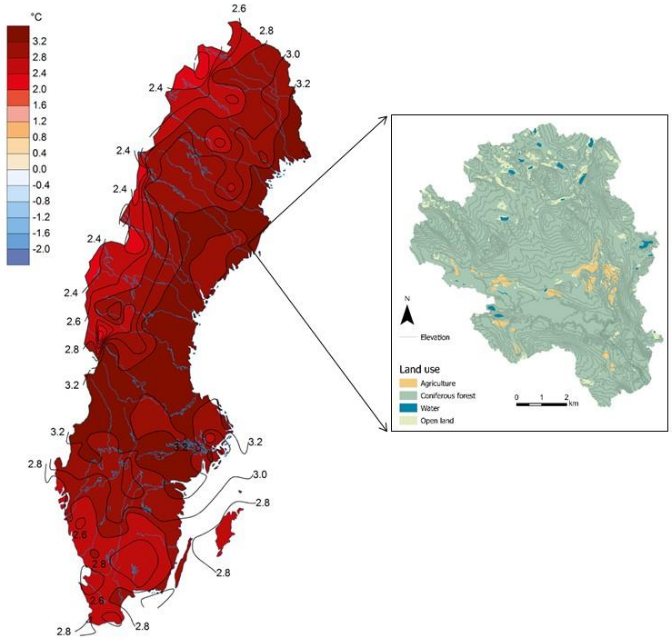


Figure 15-2:Difference of the annual mean temperature (°C) in 2020 from 1961–1990 for Sweden, position of the Krycklan Catchment with land use

Source: SMHI 2023, Lantmäteriet; https://minkarta.lantmateriet.se/)

15.2Stakeholder Interaction

The (Figure 15-3)shows the different categories of stakeholders interacted during the soil needs assessment workshops and interviews in the Upper Norrland, Sweden. The workshop took place at a central location in the region on 29 May 2023.

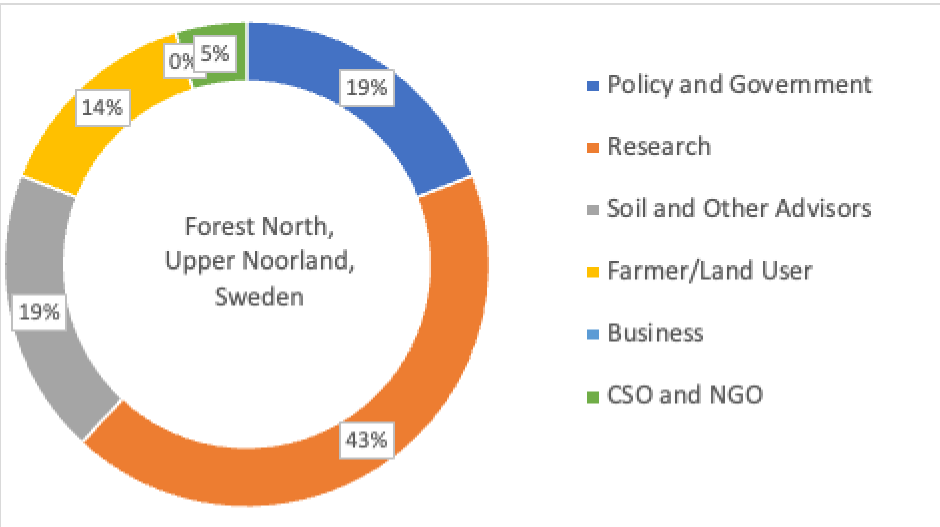


Figure 15-3:Stakeholder interaction in Upper Norrland, Sweden

15.3 Soil Need Assessment

15.3.1 Drivers

Biophysical drivers: Climate change is the most significant biophysical driver in the region. Many interviewees described the change in weather and climate as having a higher frequency of severe winds and storms, prolonged periods of drought and wet weather, and more intense rainfall. With the exception of 2010, all years since 1988 have seen higher annual mean temperatures (SMHI 2023).

Browning of freshwater: Boreal landscapes host vast areas of mires and peatlands, which are more sensitive to carbon degradation due to direct human influences (e.g., drainage) or a warmer climate than mineral soils. The increased water color, generated by increased dissolved organic carbon (DOC) due to the degradation of carbon pools in, e.g., drained peatlands, and the iron concentration forced by the leaching of Fe(III)oxyhydroxides from, e.g., podsols, has negative effects on ecosystem services such as drinking water production, biodiversity, and recreational values (Kritzberg et al. 2020).

Massive outbreaks of bark beetles leading to ecological damage to forests with simultaneous economic penalties: this biophysical driver will be supported by the socioeconomic driver of monoculture forestry, meaning that managed forest landscapes benefit the spruce bark beetle because the forest consists of large areas where all trees are roughly the same size and age. In mixed and natural forests, bark beetle infestation is of less significance. The first major evidence of an outbreak of bark beetles has been found in the Krycklan Catchment recently.

Forest fires: forest fires financially affect forest owners, especially if the forest is not insured. Values and future jobs are lost. Clearance work is costly, and the risk of accidents is high. Market opportunities for fire-damaged timber are limited. Fires not only influence carbon emissions by combustion but also by removing the carbon sink (vegetation) and by turning the burnt forest land into a net carbon source (Gustafsson et al. 2019). When fires overrun drained peatlands, especially those with a dense upper peat horizon, extensive smoldering with smoke pollution and carbon emissions can continue for a long time (Granath et al. 2016). However, burned forest land and firewood are also needed to preserve biodiversity. Forest fires can increase the risk of infestation by spruce bark beetles and other harmful insects and fungi in the forest. Whether there is an increase in harmful insects or fungi in the fire-damaged forest depends on local conditions, the severity of the fire damage, the forestry measures chosen, and the weather conditions. For middle-aged to older trees, the risk of consequential damage in the coming years is highest for spruce, but quite low for pine and non-existent for deciduous trees. In the case of seedlings, the risk of damage to conifer seedlings is high, while hardwood seedlings have a low risk of damage, except for those tree species that are more desirable to deer (SKS 2023).

Forest management strategies such as forest conversion: a change of "business as usual" strategies (forestry with monocultures of spruce and pine) could be negatively experienced in a first instance but could then lead to positive effects for biodiversity and soil health when mixed forests are implemented.

Socioeconomic drivers: Due to economic reasons for the agricultural sector (less productivity because of poor soils and a cold climate), the abandonment of arable land followed by afforestation was a typical land use change in many areas of Sweden. Modern and large-scale forestry with a high degree of mechanization placed Sweden at the top of the ranking among other "forest countries". Sweden is a predominantly forest-based country with strong property rights (48% individual owners, 24% corporates, 21% public ownership, and 7% other private owners) and a long tradition of rational forest management. Returns from forests have created Swedish prosperity and are an integral part of politics and the economy. It is therefore no wonder that forestry is the most significant socioeconomic driver in Sweden and the region.

Industrial forestry can negatively affect the soil through the work steps that are needed for felling activities, from soil preparation before to soil preparation with the planting of new trees after the felling. Driving with heavy machinery (e.g., harvesters) leads to soil damage and compaction, reducing soil porosity and lowering the infiltration capacity of water. Standing water in soil depressions (e.g., wheel tracks) with oxygen-deficient conditions can act as habitats for anaerobic bacteria and archaea capable of methylating mercury to the readily bioavailable neurotoxic methylmercury, which can imperil all life in the runoff. Aside from this point source, this problem can be ubiquitous in forest soils that have recently become waterlogged after forest harvest (cf. Eklöf et al. 2018, Xu et al. 2019) or after peatland rewetting. Measures such as the drainage of forest land are needed for productive forestry. Land use changes can lead to the decomposition of the carbon pool and, thus, the browning of the soil and runoff water (see biophysical drivers).

Worldwide, in Sweden and in Krycklan, clear-cutting is the most used and economically profitable method of logging, resulting in decreased evapotranspiration, increased groundwater tables, and therefore greater runoff with an increased load of nutrients and DOC being transported and accumulated in, e.g., downstream lakes (Laudon et al. 2011). After a clear-felling, the former forest land is sensitive to erosion by wind and water; the nutrient-rich top soil can be washed or blown away, and soil material for the anchoring of young trees and major nutrients important for new vegetation growth are missing. By using the whole-tree method, not only stems but also branches and tops will be harvested and taken out of the landscape, meaning a biomass removal and thus a limitation of organic material that otherwise would have been added to the soil. To avoid rotational forest management systems such as clearcutting, more sustainable forestry and harvesting strategies, e.g., continuous cover forestry (CCF), are tested.

Independently from the state of the soil, one interviewee, a private forest owner, described that forest land productivity with respect to forest timber yield per hectare and year has increased. This change has mainly come due to the use of refined plants, more intense management, and an increased level of fertilization. The same forest owner has developed and implemented a new forest governance strategy where ecological ambitions are significantly higher than for the Swedish standard and where clearcutting is restricted to a maximum of 50% of the productive forest land. Mono- and biculture forestry lead to decreased biodiversity and the vulnerability of the forest to infestations (see bark beetle in biophysical drivers). Moose destroys (eats) young pine forests. Therefore, spruce is planted extensively in many regions.

Sweden and Finland have the largest share of forest in Europe, and the Scandinavian forests are different from the much older deciduous forests of other countries. This means that the biodiversity of Scandinavian forests is different from that of central European deciduous forests. When legislating on climate and environmental issues, different types of forests and biodiversity should be taken into account, but this is not done in the EU today (Skogssällskapet 2022).

15.3.2 Pressures

Because forestry in Sweden is mostly done on the poorest soils that can hardly be used for other land uses, the “upgrade” to a better soil type through pedogenesis under forestry is not possible. To maintain the soil health of boreal soils, sustainable forest management with reduced impacts on the soil combined with increased productivity (more timber for substitution of other materials and fossil fuels) should be achieved instead. Many forest owners and organizations are aware of the urgently needed adaptations to climate change, such as the establishment of mixed forests, continuous cover forestry, and measures to minimize driving damage. One interviewee is increasingly demanding a change towards a governance of forest land with ecological functionality as a guiding principle and timber harvest as a second priority. Another stakeholder mentioned that old-growth forest only exists in protected areas and that natural regeneration is hardly found.

For the forest conversion and for supporting the environmental objective "living forests" (Sveriges miljömål 2023), the replacement of coniferous monostands would be a desired pressure that could continue in the future until more natural forest stands have been developed. This may result in financial penalties for the forest owners. The first major evidence of an outbreak of bark beetles has been found in the Krycklan catchment. Close collaboration between the scientific community and the affected landowners makes it possible to follow the buildup, onset, and outbreak, as well as test different prevention and countermeasures.

Drained peatlands contribute to large greenhouse gas emissions in agriculture and in land use, land use change, and forestry (LULUCF) sectors in Europe. Rewetting drained peatlands is seen politically as a climate-smart mitigating measure because GHG emissions can be lowered by returning them to carbon sinks, thus achieving the environmental objectives 'Reduced Climate Impact' and Wetlands'. However, rewetting is often accompanied by the enhanced release of toxic metals (methylmercury) and phosphorus. This negative effect offsets the environmental objective of 'zero eutrophication' and is seen as a pressure or hindrance for direct implications in the management of drained peatlands.

15.3.3State

During the workshop, it was discussed what to consider "healthy" soil. If this could be related to the forest ecosystem on those soils, then Sweden and Krycklan have developed ecosystems on naturally very nutrient-poor podsols and on morainic gravel material without any soil, but also on nutrient-poor drained peatlands. To operate industrial forestry on low-quality soils per se (compared to fertile soils in other European countries), most of the stakeholders would not consider the soils in the Swedish case to be in an "unhealthy" state. Two interviewees regarded their forest soil as in "pretty good shape as judged by a very high level of productivity". Problem statement of biophysical situation: High-latitude regions have the largest standing soil carbon stocks and are therefore very sensitive to warming-induced carbon losses (Crowther et al. 2016; Figure 15-4 and Figure 15-5).

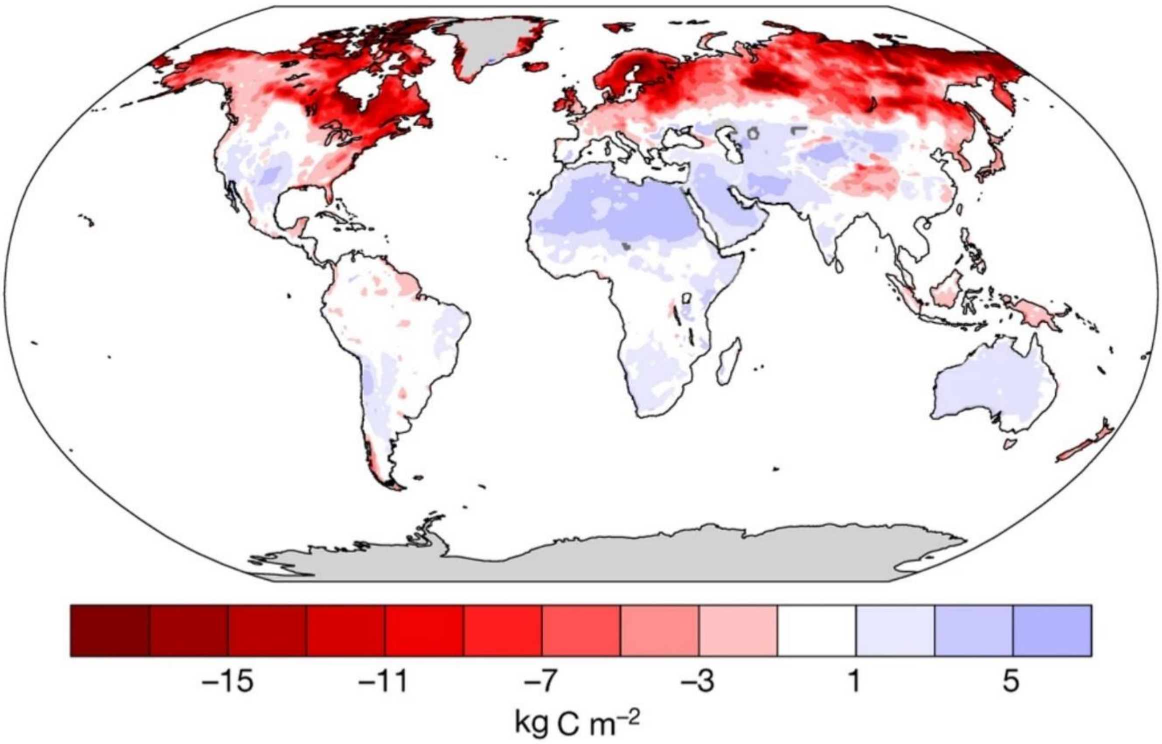


Figure 15-4:Global patterns in the vulnerability of soil carbon stocks (kg C m-2) at 0–15 cm depth by a soil surface temperature change of 1 °C (Crowther et al. 2016). Regions in red indicate a high sensitivity of carbon stocks to a warmer climate.

The Krycklan catchment hosts large areas of peatlands, which, under rising temperatures, can emit more carbon gases as they are bound as carbon in dead organic material (peat). The man-made drainage of peatlands for land use will strengthen and accelerate the vulnerability of the peat (Figure 15-5) to oxidation with simultaneous greenhouse gas emissions and land subsidence.

Figure 15-5: The Scandinavian landscape soil carbon stock losses.

Stakeholders from the Forestry Research Institute of Sweden (Skogforsk) stated that the soil organic matter in mineral forest soils has increased over the last decade, that the fire-fighting system is highly developed so that forest fires are not seen as a problematic issue, and that new ditching is forbidden and only ditch maintenance is allowed. Further, the theoretical knowledge about the evolution and importance of greenhouse gases and the practical knowledge on how to measure them, especially for forest soils, have increased exponentially. Here, Krycklan works as a prime example (Krycklan Catchment Study (KCS) | Externwebben (slu.se)). Skogforsk also mentioned that forest owners are aware of driving damages and that no chemicals are used any longer to protect the plants. Soil acidification decreased due to the effective filter devices for sulfur in the industrial plants in Sweden but also worldwide. Some private forest owners have observed decreased water retention capacity and soil compaction from machinery. Another interviewee is aware of the importance of vegetation cover all year and avoids bare soil. ("Something always grows after a forestry operation. I like shifting forest-floor vegetation").

Socioeconomic situation: With the revision of the Forestry Act in 1974, environmental and production objectives became equalized, meaning that environmental considerations must be taken into account in all forest operations. In addition, environmental protection became a mandatory subject in forest education (Hasselquist et al. 2020).

Stakeholders from Skogforsk explained that more often, branches and tops as logging residues are left in the forest if only the stem wood is taken out. By leaving these residues on the soil, we can somewhat compensate for the amount of nutrients removed through felling. Tops and branches are also used as soil cover when driving heavy machinery. Nowadays, it is also mandatory to leave protection zones in waterways when harvesting (Figure 15-6). Trees were certified for traceable documentation of origin and life cycle (often pressured by organizations for environmental consideration).

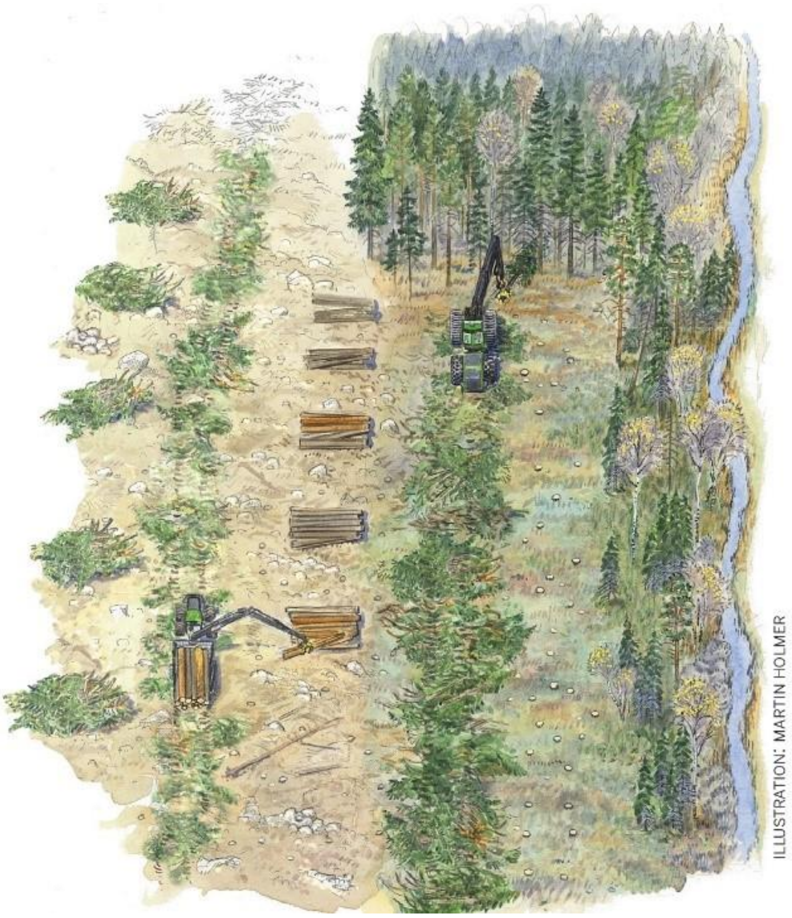


Figure 15-6:Preferred driving style at harvesting near water and under non-frozen soil conditions.

Tops and branches cleaned from the stem are used to make the ground more solid and to prevent the occurrence of driving damages. Observe the trees in the protection zone close to the stream (Skogsstyrelsen 2023).

Skogforsk also pointed out that the forest rotation time was lowered and that the forest had to grow denser for higher production. Hard economics did not leave freedom for creating and affording a nice forest park: “one is guilty of cutting down the forest”. Nowadays, clearing the soil ("markberedning") is almost banned to minimize soil damage. Harvesting was previously done only in the winter when the soil was frozen, but it is a current method all year round nowadays.

Stakeholders from the Swedish Forest Soil Inventory indicated that knowledge about the relationship between carbon storage in trees and soil is essential when discussing forestry on mineral soils and on drained organic soils (peatlands). The Swedish Forest Soil Inventory (About the Swedish Forest Soil Inventory | Externwebben (slu.se)) and the Swedish National Forest Inventory (The Swedish National Forest Inventory | Externwebben (slu.se)) are two country-wide programs describing the state and changes in Swedish forests and forest soils.

15.3.4Impacts

The above-named drivers "climate" and "forestry" are directly related to the manifold ecosystem services provided by (Swedish) forests in general and for the Krycklan catchment in detail, which are:

- the provision of food, fiber, and biomass for energy and material production and as a substitute for fossil resources
- the provision of mushrooms and berries
- the improvement of the regional landscape hydrology, including water purification and water flow regulation
- the support for biodiversity and natur
- the drinking water resources
- the mitigation of regional climatic change by providing additional evapotranspiration cooling
- the climate regulation by carbon sequestration in the mineral forest soil
- hunting as well as providing habitat for reindeer and moos
- recreation

Further, the provision of sand and gravel and soil related to cultural services are important ecosystem services of forest soils.Whereas the socioeconomic driver "forestry" with the widely used method of clear-cutting would negatively affect all ecosystem services (until their total destruction) at a site for the time between the rotations, it is of importance to find and practice sustainable harvesting methods for forestry. The biophysical driver "climate", with the many scenarios of conditions (too wet, too dry, too warm, too cold, too windy, and extreme weather), would harm some of the ecosystem services or would lead to a shift of, e.g., different species in flora and fauna within certain services. It is very unrealistic to proceed with forest conversions that suit all climate change scenarios. However, both drivers are coupled to each other and must be taken into consideration together when judging a single one.

15.3.5 Response

Even though much knowledge about forest soils, their uses, and the need for a future sustainable interaction exists, a critical mass of the public who is aware of the above-named drivers and pressures is lacking. One interviewee responded to the question "Is there public awareness and/or reaction to the drivers, pressures, and impacts that were identified?" with "About forest yes, about forest soil no." This statement makes it clear that a broad mass of people in our society are not related to soils because soils are seldom visible. Therefore, soil literacy is important to raise people's awareness of things they do not experience in their daily lives (the stakeholders involved in the study are very aware of the conditions of forest soils). During the interviews, it was discovered that advisors in the forestry sector also lack knowledge about forest soils.

Many Swedish organizations related to forest and forestry have published material (often in easily understandable Swedish) about how to sustainably use our soils. "Driving on the ground instead of in the ground" is a very educative short film about minimizing soil damages during harvesting activities (Traceless – a step towards a forestry without soil damages: https://www.skogforsk.se/english/news/2017/traceless--a-step-towards-a-forestry-without-soil-damages/). The Swedish Forest Agency published a short manual about "How to drive on forest soils" (Körning i skogsmark; 2016).

The many stakeholders showed their different visions for future forestry. Whereas one person will continue on the same track with mixed forest and self-reproduction when selecting the strongest plants in a long-term plan, another stakeholder responded to the future land use performance very cautiously: "Important short-term economic gains with increased forest stock and increased forest productivity in material wood mass, but with severe future risks for deteriorated forest land functionality". Obvious to many was the position of having the right tree on the right land and that it is important to have mixed forests. The market for deciduous trees must be expanded.

For many involved stakeholders, the Paris Agreement and the European Green Deal are starters, but not at all enough. Path dependency has been seen as the main barrier to positive transition activities. People like to stick to confirmed habits. "It is difficult to go back to small-scale picking trees here and there" when "climate change is placing additional demands on forests to provide biomass as a substitute for fossil fuel" (Söderberg and Eckerberg 2013 in Hasselquist et al. 2020).

15.4 Conclusions

As indicated before, forestry on nutrient-poor soils and on rocky morainic material is without concurrence with any other land uses. Through refined forest management with soil conversational measures, potential negative impacts such as soil damage and compaction can be reduced. The fact is that modern forestry needs to increase the production of forest biomass to potentially help mitigate predicted climate changes (Laudon et al. 2011). Forestry on drained peatland should be avoided because greenhouse gas emissions counteract carbon sequestration in the wood biomass and in the mineral soil.

15.5 Refereces

Björheden, R. (2019): Climate impact of Swedish forestry: Absorption och emissions of carbon dioxide. Skogforsk, 24 p. https://www.skogforsk.se/cd_20191216101138/contentassets/01f064719a434ecda8fcf0a0956755dc/climate-impact-of-swedish-forestry.pdf

Crowther, T., Todd-Brown, K., Rowe, C. et al. (2016): Quantifying global soil carbon losses in response to warming. Nature 540, 104–108 (2016). https://doi.org/10.1038/nature20150

Fredén, C. (spec. ed., 1994): Geology. In: WASTENSON, L., HELMFRID, S., ARNBERG, U., ELG, M. & SYRÉN, M.: Geology. Sveriges Nationalatlas; SNA förlag Stockholm, 208 p. https://unstats.un.org/sdgs/metadata/files/Metadata-15-01-01.pdf

Eklöf, K., Bishop, K., Bertilsson, S., Björn, E., Buck, M., Skyllberg, U., Osman, O.A.,Kronberg, RM., Bravo, A.G. (2018): Formation of mercury methylation hotspots as a consequence of forestry operations. Science of The Total Environment 613: 1069-1078.

Granath, G., Moore, P., Lukenbach, M., Waddington, J.M. (2016): Mitigating wildfire carbon loss in managed northern peatlands through restoration. Sci Rep 6, 28498. https://doi.org/10.1038/srep28498

Gustafsson, L., Felton, A., Felton, A.M., Brunet, J., Caruso, A., Hjältén, J., Lindbladh, M., Ranius, T., Roberge, JM, Weslien, J. (2014): Natural Versus National Boundaries: The Importance of Considering Biogeographical Patterns in Forest Conservation Policy. Conservation Letters 8(1), 50-57.

Gustafsson, L. et al. 2019): Rapid ecological response and intensified knowledge accumulation following a north European mega-fire. Scandinavian journal of forest research 34(4), 234-253. https://doi.org/10.1080/02827581.2019.1603323

Laudon, H., I. Taberman, A. Ågren, M. Futter, M. Ottosson-Löfvenius, and K. Bishop (2013): The Krycklan Catchment Study – A flagship infrastructure for hydrology, biogeochemistry, and climate research in the boreal landscape, Water Resour. Res., 49, 7154-7158, doi:10.1002/wrcr.20520.

FAO (2020): Global Forest Resources Assessment, Terms and Definitions https://www.fao.org/3/I8661EN/i8661en.pdf (retrieved September 20th 2023)

Hasselquist, E.M., Mancheva, I., Eckerberg, K., Laudon, H. (2020). Policy change implications for forest water protection in Sweden over the last 50 years. Ambio 49, 1341-1351. https://doi.org/10.1007/s13280-019-01274-y

Kritzberg et al. (2020): Browning of freshwaters: Consequences to ecosystem services, underlying drivers, and potential mitigation measures. Ambio 2020, 49:375–390https://doi.org/10.1007/s13280-019-01227-5

Lantmäteriet (2023): https://minkarta.lantmateriet.se/)

Laudon et al. (2011): Consequences of More Intensive Forestry for the Sustainable Management of Forest Soils and Waters. Forests, 2, 243-260; doi:10.3390/f2010243

Lindahl, A. & Lundblad, M. (2021): Markanvändning på organogena jordar i Sverige: En översikt av markanvändning, och förändring i markanvändning, på organogena jordar inom jordbruksmark och skogsmark. SMED Rapport Nr 21, 1-140.

SFIF (2018): Facts & Figures. Swedish Forest Industry Federation http://www.forestindustries.se/forest-industry/facts-and-figures/.

Skogsstyrelsen (2023): https://www.skogsstyrelsen.se/bruka-skog/skogsskador/skogsbrander/skogen-kan-gynnas-av-brand/

Skogsstyrelsen (2016): Körning i skogsmark. https://www.skogsstyrelsen.se/globalassets/mer-om-skog/malbilder-for-god-miljohansyn/malbilder-korning-i-skogsmark/malbild-korning-i-skogsmark.pdf

Skogssällskapet (2022): https://www.skogssallskapet.se/kunskapsbank/artiklar/2022-06-15-sverige-och-finland---tva-udda-faglar-i-eus-skogspolitik.html

SMHI (2023): SMHI LuftWebb (Sweden's meteorological and hydrological institute), https://www.smhi.se/data/miljo/luftwebb/ (in Swedish), accessed 01.08.2023

Statistics Sweden (2019): Land use in Sweden. 187 p. https://www.scb.se/contentassets/eaa00bda68634c1dbdec1bb4f6705557/mi0803_2015a01_br_mi03br1901.pdf

Söderberg, C., and K. Eckerberg. (2013): Rising policy conflicts in Europe over bioenergy and forestry. Forest Policy and Economics 33: 112–1193 https://sverigesmiljomal.se/miljomalen/levande-skogar/

Xu, J., Buck, M., Eklöf, K. et al. (2019): Mercury methylating microbial communities of boreal forest soils. Sci Rep 9, 518. https://doi.org/10.1038/s41598-018-37383-z

16 Forest Tourism South East: Antalya, Türkiye

Prof. Ertuğrul BİLGİLİ1, Prof. Turgay DİNDAROĞLU1, Prof. Tuğrul YAKUPOĞLU2, Assoc. Prof. Uzay KARAHALİL1

1Karadeniz Technical University, Faculty of Forestry, 61080, Trabzon, Türkiye 2YozgatBozok University, Faculty of Agriculture, Yozgat, Türkiye

16.1 Regional Information

Köprülü Canyon National Park (NP) has outstanding landscape features such as typical unequal and valuable forest stands, habitats for wildlife, valuable sites for culture and interesting geomorphology. The area includes Köprüçay creek as an ecotourism potential with an ongoing rafting and canoeing activities in the lower part of the creek. There isin the area an important ancient city of Selge having a theatre and a bazaar. The park is exceptional in terms of vegetation cover, historical structure, aesthetics, eco-tourism and social aspects. In short, Köprülü Canyon NP accommodates many visitors reaching 8000 people per day in the peak season, as well as a large number of endemic plants and rare animal species, archaeological and historical ruins, and rich habitats in the province of Antalya located in the Mediterranean region.

The park is very sensitive to forest fires having a pervasive influence on the stability of the ecosystems and adjacent to the acute Serik-Taşağıl and Manavgat wild fires, were broken out in 2008 and 2021 and destroyed several villages with nearly 75,000 ha of forest areas in total. Although forests area is increasing over the last decades, the structure and composition is degrading in sensitive areas under the effects of climate change. That phenomenon affects future land use composition as well. Three main land use namely; protected area (tourism & recreation), agriculture and forestry dominates the area where tourism & recreation is clearly dominant.

It is widely recognized that land use patterns and their impact on soil have changed significantly in the last decades. Climate change might improve, reduce, or shift the soil suitability within the park. Therefore, it is very crucial to display the status of the soils and to explore current and future effects of the climate change on soils. There are three distinct land use patterns within the park namely; tourism, agriculture and forestry. However, mentioned land use have certain effects on the soil health with the help of a series of drivers where climate change is prominent.

16.2Stakeholder Interaction

To discuss current management practices and land uses driven by external factors or drivers that put pressures on the current state of soil functions, we conducted a workshop in Antalya on 26.04.2023. Prep Soil Turkish team conducted the workshop in Regional Directorate of Forestry in Antalya where high level forest managers, local people and stakeholders attended. The workshop concentrated on the local stakeholders (Figure 16-1). The focus was mainly about the introduction and analysis of the drivers, pressures, state, impacts and response of the region related to soil health. The objectives of the workshop were to:

- understand the potential to increase the livelihoods of people living at the edge of the forest, enabling them to earn a better income,
- discuss soil management and the sustainability of using more water and fertilizer to achieve the same amount of product, as the soil in the region is gradually losing its health,
- examine the impact of tourism and agricultural activities on the forest, as well as the impact of the protected forest on tourism and agricultural activities,
- additionally, discuss the experiences of forestry policy practitioners in the region and European knowledge projects implemented in the past, which aimed to strengthen the local workforce and market share, and
- finally, assess the potential implementation of alternatives by involving stakeholders

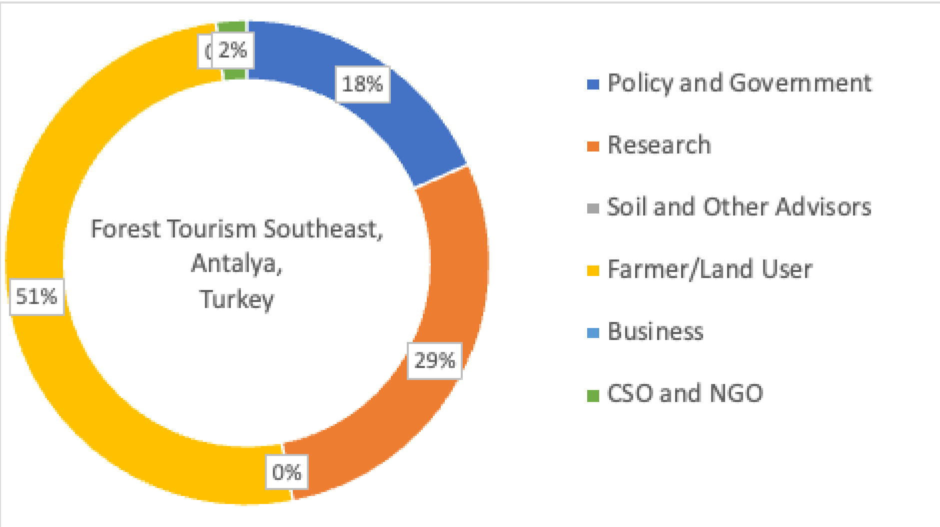


Figure 16-1:Stakeholder interaction in Antalya, Turkey

16.3 Soil Needs Assessment

16.3.1 Drivers

Biophysical driver: The conducted workshop revealed 3 distinct focus groups: forestry, tourism and agriculture in the Köprülü Canyon National Park (NP). The “tourism” focus group considers the first ranking land use as "forest" and accepts the purpose of this land use as "tourism". Land use and land use change in the region are generally shaped by climate affecting different biophysical drivers such as water availability, soil fertility or wildfires.

Climate change: Considering the perception of climate change impacts, it can be noticed that there is a strong awareness of climate change impacts on Köprülü Canyon NP, with nearly all participants perceiving that climate change will continuously affect their region. The level of awareness about seasonal tendencies is high among those who perceive seasons to be warmer. Furthermore, most people think that seasons are occurring later than before. It is noted that stakeholders perceive an increase in temperature and less precipitation (rain and snow). According to attendees, the annual mean temperatures around NP will show an increasing trend in the next 50 years and the long-term change of extreme temperature events will continue to occur in the area due to climate change.

Water availability: The perception of water availability is shared by local people and forestry professionals who believe that there is less water available in forest soils now compared to the past due to climate change. The decreased water level affected in some years rafting and canoeing activities. But, the status of the sites, protected areas, historical sites, geological formations as well as stream beds have not changed. They noted an increase in insect attacks on trees in their forests and a higher frequency of fires. Also the interest group believes that trees and crops are growing slower now compared to the past due to lower water availability. Stakeholders think that maintaining the multiple ecosystem services such as water production and filtering, water conservation, carbon sequestration, soil control, non-wood forest products (thyme) and timber production, in a satisfactory quantity and quality over the next decades will be harder than today. The future outputs of the ecosystem services in terms of water availability and regulated water flows will show a similar negative pattern in the coming years according to interest groups.

Soil fertility: In the agricultural land, the dominant plants are grains and fruits (olives). In addition to olives, carob and figs are also grown. The purpose of land use is mostly self-consumption. There has been a change from forest to field and from field to garden. The most important constraints are nutritional requirements and insufficient human resources. Land management has changed as a result of the main land use change from forest to agriculture, which mostly depletes the already poor soil health even more by the use of agro-chemicals, ploughing and soil erosion.

Wildfire: As part of the biophysical drivers in the region, wildfires are important natural disturbance agents. Fire plays a crucial role in the Mediterranean forest ecosystems, shaping their structure, composition, and overall functioning. Ecosystems in these regions have evolved with a long history of fire occurrence, and many plant and animal species have adapted their life cycles and characteristics to the presence of fire. Given the potential change in climate in the future, more destructive and high intensity fires may be more frequent, leading to a change in natural fire regimes which in turn lead to a change in structure, composition, and overall functioning of ecosystems.

It is important to note that while fire is a natural part of these ecosystems, it can also pose risks to human communities and infrastructure. Balancing the ecological benefits of fire with the need for fire management and prevention is a crucial challenge in these regions prone to wildfires. As for the management of these areas, the natural age class structure shaped by natural fire cycle can be referenced for setting a forest rotation age. Wildfires have led to the loss of lives and livelihoods of inhabitants, as well as the destruction of villages, creating lasting effects at the social and individual levels. Economic development of the local people can be achieved by diversifying tourism activities, which have a certain potential.

S**ocioeconomic driver/issue:** The participants emphasized a series of socio-economic drivers related to main three distinct focus groups.

Income: Climate change is evident in the form of drought and reduced rainfall. All these developments have led to changes and decreases in agriculture and animal production. The decline in soil health (soil erosion and droughts affecting soil biodiversity) has resulted in decreased production levels, leading to a decrease in income and subsequent economic and social disadvantages. There has been a shift from agriculture to tourism, which has occurred gradually in response to supply and demand. People have turned to the tourism service sector as it brings in more income. The increase in tourism has resulted in a decrease in agricultural activities. The transformation has almost taken place and no increase is expected in the agricultural sector compared to tourism in the future.

Tourism/industry change: The region is also a tourist attraction. In general, agricultural activities have decreased, while tourism activities have increased in the region. The number of tourists reach nearly 3000-5000 daily especially in the July-August season. Under the scope of the European Union and World Bank supported project, initiatives have been started to enable local people to make their living by selling local products. As part of the GEF II Project's 'Biological Diversity and Resource Management Project', a product design for the weaving workshop in Köprülü Canyon Demirciler Village was created in 2007. The Selge Branding project focuses on villages located within the borders of Köprülü Canyon National Park (KKMP) and in its buffer zone. The project aims to promote sustainable development and ecosystem protection by branding products made using traditional methods by women living in and around KKMP's villages. The gradual decline of agriculture in NP due to tourism pressure is a serious problem. But this process can be managed correctly. For example, with solutions such as the ecological village approach, tourism and agriculture can be integrated. With such workshops as the one organized by PREPSOIL, awareness of the local people should be increased and their access to information should be facilitated.

Land ownership: The forests in the region have been included in the National Park, but ownership of all land surface is not clear and causes conflicts and serious problems in land use. While the National Park authority has gained tourists by protecting the outstanding forest vegetation of the national park, attempts from local people to take advantage of the income generated from the national park to meet their subsistence needs and generate cash income have remained limited. This situation has manifested itself in two different ways. Firstly, livestock husbandry has become an increasingly risky pursuit over time due to the limited grazing pastures and agriculture lands after the declaration of the NP. As a result, households sought other sources of income, such as migration of the younger generation for wage labor in urban areas. Secondly, diversification of livelihoods was necessary for the poor people, such as landless individuals or those with least access to farmland, to combat income instability and increase the probability of maintaining livelihood security. Consequently, some villagers found themselves working in tourism services. The solution to cadastral problems may lead to different results, including some increase in efficiency in agricultural areas in the next decades. However, no such effort is on the horizon.

Labour shortage: The people in the region are involved in silvicultural activities in nearby forest areas. However, due to labor-intensive work, insurance problems, and seasonal working conditions, people are not willing to engage in forestry activities. The socio-economic losses, coupled with threats to local people and tourism, may lead to a potential decrease in tourism activities and employment opportunities for locals. This could further impoverish low-income individuals. One of the most important points here is to solve the social security problem of the people living in the region and those who will contribute to its development.

Government effectiveness: Respondents stated that they have not received any subsidies or support from the European Union, the national government, or other institutions and organizations within the region. They also mentioned that there have been no meetings or initiatives on this subject other than the workshop. Local community representatives declared that they are not aware of any regulations or laws governing land or land management, and they have no information in this regard. They are also not aware of new technologies or management strategies applied in land use to improve production or reduce impact.

16.3.2 Pressures

The intertwining of residential areas, forests, protected areas, and tourism areas creates management problems. Reduced water availability and quality: Decreased water availability is attributed to climate change as well as water misuse in NP. Changing rainfall patterns necessitate changing irrigation habits and practices. There is no written regulation or obligation regarding the use of a 'pressurized pipe irrigation system' that can minimize water loss, although this system is recommended for agricultural areas. The main barriers for farmers are economic difficulties and water scarcity. There is an awareness that organizations within the Ministry of Agriculture are responsible, and there is an equal situation with or without public awareness. Although there are support programs available for farmers, they are insufficient, and many farmers are not registered with the ÇKS (Turkish farmer record system).

Both drought and excessive rainfall can impact water quality. Reduced amounts of water in river during dry months leads to higher concentrations of pollutants. This leads to a decrease in water quality. Warmer water means less oxygenated water. The decrease in dissolved oxygen levels, one of the most important determinants of water quality, brings serious pollution problems. Therefore, global warming and climate change affects not only the quantity but also the quality of water resources. With the increase in temperature, pollution concentrations can rise due to decreased precipitation and flows, leading to water quality issues. This phenomenon leads to a decrease in the number of tourists engaged in rafting and canoeing activities and results in a declining revenues.

Moisture stored in the soil is vital for agriculture, and the evaporation rate directly affects groundwater recharge and runoff water production. The observed localized effects of global warming on soil moisture vary not only based on the rate of climate change but also with soil properties. The water-holding capacity of the soil influences possible changes in soil moisture deficit. When the capacity is low, its sensitivity to climate change is high. Climate change also affects soil characteristics through water absorption or cracking properties, phenomena that reveal the moisture storage properties of the soil.

The decrease in water resources due to climate change will have a negative impact on agricultural production in the future. In addition to the expansion of arid and semi-arid areas, the increase in the average annual temperature will lead to desertification, salinization, and erosion in the NP.

Increased disease/insect outbreaks: Forest fragmentation also increases the temperature within the forest, exacerbating the effects of global warming and leading to increased disease occurrence in forest trees, such as chestnut branch cancer, pine processionary moth, and pine bark beetle, as well as drying out in NP.

Tourism activities/expanded road networks/mechanization in agriculture: Tourism activities in the region put additional pressure on forest areas. Activities such as canyon trips, rafting, safari tours, and restaurant businesses have a negative impact on the forest area and, consequently, on the health of forest soil. Previously, the region was primarily focused on agriculture and forest utilization, without tourism activities within the park. However, recently, the allocated areas for tourism have significantly increased while agricultural areas have decreased. Although agricultural activities have declined, mechanized processing is still being carried out. Tractors, which were not commonly used in the past, are now present in almost every household. With the development of tourism, there has been a diversification of activities over time. In addition to rafting and canoeing, vehicles like "Buggy" and "ATV" are now used. These changes have led to modifications in the physical environment, including the allocation of new areas for tourism services. Changes in equipment use have also been observed in this context. People have recognized these changes in the tourism sector by seeking advice, keeping up with innovations, and considering guest demands. Workshop participants mentioned that they were not informed about management practice innovations, and there was no regular information mechanism or channel to keep them informed. With this increasing activity both in field traffic and tourism routes, the risk of soil compaction has come to the fore. Participants think that the increase in tourism activities will bring expansion of road/trail networks and will increase soil erosion. The expansion of in-forest road/trail networks for safari tours will fragment forest areas, which has a detrimental effect on soil health.

Rise in temperature: The rise in temperatures and the resulting soil dehydration can cause the soil to crack and split, which can negatively impact its workability, particularly in cultivated areas. According to researchers and some farmers who attended PrepSoil workshop, these changes are expected to have several implications for plant physiology in the future. These include alterations in growth patterns and structural dynamics, a reduction in transpiration loss, changes in the root-to-stem ratio dynamics, and an increase in water stress-related problems.

16.3.3State

Biophysical situation: Low soil fertility, suboptimal crop yields and water availability: Compared to the past, it has been stated that the soil is currently in an unproductive and deteriorating condition. Participants emphasized that both public observations and the assessments of authorities such as the “Provincial Directorate of Agriculture” and “District Directorate of Agriculture” support this observation. In the past, irrigation systems were established, which enabled sufficient crop yields. However, over time, the amount of water used and obtained decreased gradually, resulting in the malfunctioning of these systems and reduced crop production.

Reliance on fertilizer application: The use of artificial fertilizers have become more prevalent and encouraged. Nutrient run-off from farms laced with synthetic fertilizer has adversely affected land ecosystems. Human health is also at risk. However, initiatives to stake out a more sustainable way of growing food are limited in the NP. Currently, those engaged in production activities rely on artificial fertilizers.

Water pollution and drop in water levels: With the increasing tourism activities and the change of land cover, more erosion and high amounts of suspended sediment are observed in Köprüçay creek. It is stated that the water is not as clear as before. In addition, irregularity in the amount of precipitation manifests itself as a decrease in water levels. Considering that tourists come to the NP mainly for rafting and canoeing, this is an important finding. The geological area of the NP made up of a porous rock composed of calcium carbonate constitutes a remarkable example of a karstic landscape. Köprüçay creek surface flow is usually smaller than the below ground flow.

Socioeconomic situation: The villages in the area have poor housing conditions: Altınkaya Village is built entirely on an ancient city and is classified as a First Degree Cultural Site. Therefore, any changes or modifications to the houses or the village require permission, and some actions may even be prohibited. Currently, there is still no water network reaching the houses, and the toilets are located outside.

Low income: In Köprülü Canyon National Park, people are employed in low-paid services such as night watchman, tractor driver, boat guide, and rowing. However, the people who make a living from tourism are unemployed outside the summer season, and a large part of the income does not stay in the region. Overgrazing and poaching are also carried out in the region, and the wood needed is obtained from the forest. Unfortunately, unlike ecotourism management where control is of great importance at every stage, there are uncontrolled tourism activities in the national park.

Abandoned agriculture lands: Due to the growth of tourism activities in the NP, the local community experienced the benefits of tourism in addition to agricultural activities. As tourism matured, some individuals chose tourism over agriculture, leading to the abandonment of agricultural activities due to the perceived benefits of tourism. Unfortunately, tourism did not develop in the form of agro-tourism, which caused farmers to give up their agricultural pursuits. Additionally, many traditional agricultural systems are now under severe pressure from globalization and inadequate government intervention. This has resulted in the loss of more farms and a lack of willingness among farmers to engage in agricultural activities due to unfamiliarity and lack of government support. This is due to the resource policies in the country that have prioritized service and industrial sectors as economic development driving forces.

Intense tourism activities: Köprülü Canyon NP accommodates many visitors reaching 5000 people per day in the peak season. In addition to its archaeological and geological treasures, this park is mainly used for rafting and canoeing. The use of Köprülü Canyon NP is likely to be influenced according to the outdoor recreational requirements of urbanized societies, due to the park's proximity to a tourism center and a large city of Antalya, and availability of transportation facilities. Unplanned uses help to destroy the natural balance and put into danger the sustainability of the park.

Lack of subsidies and knowledge as barrier to sustainable management: Farmers state the level of subsidies are insufficient. While they are aware of the existence of laws and regulations related to land management, they lack knowledge about the specific content. Although they possess the know-how to manage their land, their resources are limited. They are not fully aware of the physical environmental changes caused by land use changes. They believe that in the future, mechanization will become more prevalent, and migration may be inevitable. Additionally, they express the need for government support to achieve their desired state. In fact, what drives the local people to change land use is not the unconsciousness of the farmers, but the increase in tourism pressure as a result of the decrease in income obtained from agriculture due to legal inadequacies and the lack of government support.

16.3.4Impacts

Changes to accommodate tourism: Participants stated that local people have abandoned farming and turned to tourism, which has increased pressure on soil and forest health. They emphasized that when activities such as hiking, safari, camping, and other forest-related activities are not planned and controlled properly, they cause soil erosion and have the potential to impair soil health. They also mentioned that the region's rugged topography increase soil erosion and lead to organic matter deficiency in the soil. Scientific publications have highlighted that the lack of organic matter adversely affects soil health and fertility. Furthermore, it was noted that the construction of safari roads has fragmented the forests. This situation result in habitat loss and soil erosion. As a result, the group concluded that the cumulative effect of these factors cause significant health problems in the soil. However, soil health continues to decline. Improving soil health can provide economic and social advantages, leading to increased production and income. It can also have a positive impact on tourism, as clean water is crucial for tourism activities. Turbid water negatively affects tourism, as tourists prefer clear water. If tourism declines, agriculture and forest activities may increase. Deteriorating soil health leads to uncultivated land and reduced land performance.

Impact of agricultural practices: Farmers are aware that healthy soil provides clean water and well-being. They understand the importance of using organic waste as fertilizer to keep water resources clean and maintain healthy soil. They recognize that healthy soil yields higher productivity per unit area and understand the relationship between soil health and a balanced diet. They adopt an approach that considers soil as a source of wealth. However, economic factors can still influence changes in land use, even if the soil is healthy. The measure of land use performance in healthy soil is productivity.

Participants believe it is essential to consider changes in land use approaches and their effects on forest ecosystems' structure, composition and functions. They expressed concern about the significant increase in the use of artificial fertilizers in recent years. They emphasized the importance of using organic fertilizers to ensure productivity, which can also promote carbon storage and have positive impacts on other aspects such as bee presence. Soil health also has a positive impact on organic nutrition. Forests play a vital role in oxygen production and provide psychological health benefits, contributing to mental well-being.

Impacts from climate change: The unconscious use of water in agriculture negatively affects the tourism sector. Unconscious water use refers to the situation where a significant portion of the water budget is allocated to agriculture, leaving less water available for tourism. Additionally, incorrect water use can lead to land degradation, which has adverse effects on both agriculture and tourism.

Migration: According to the tourism group, the continuation of the current situation and increased infertility could lead to the lower elevations near the coastline becoming less fertile, causing people to migrate to higher areas such as the National Park. It is believed that this will also have an impact on tourism and water supply.

Forests in the region experiences adverse impacts, such as a decrease in the area covered by certain tree species, due to changes in their natural habitat conditions. Some of these impacts may be potentially irreversible. Climate change has the potential to alter the climatic habitat suitability of certain species, either improving, reducing, or shifting their suitable habitats. These changes will affect the future composition and configuration of the forests.

16.3.5Response

Dialogue and collaboration among different stakeholders, which can help create a shared vision. Policy changes and incentives can encourage efforts towards the conservation and sustainable use of forests. Ongoing transition activities in the region also present important opportunities for forest protection and management. These activities are crucial for evaluating and improving options for soil health.

Public awareness regarding healthy soil and fertile lands. Improving soil health increase production, income, and achieve economic and social advantages. Increasing irrigation canals or systems and promoting the use of organic fertilizers enhance productivity and reduce pressure on forests. Develop animal husbandry in the region. They suggested that organic fertilizers can be used in various areas, including forests, to be beneficial. Furthermore, the adoption of mechanization can contribute to achieving these objectives.

- Better regulations for picnicking visitors, which would also have a positive impact on tourism and ensure more abundant and cleaner water.
- Adopting silvicultural practices such as planting more tolerant tree species and building mixed stocks of tree species in forest stands to help forests adapt to future climate change. Local residents willing to follow advise on climate resilient agriculture and forestry.

Take action now: Precautions should be taken now, and adaptive policies should be developed to manage changing environmental conditions. Establishing an adaptation system that monitors disturbances and integrates international policies, national legislations, regional and local realities is crucial to enhancing society's adaptation capacities. All stakeholders, including local communities, forest owners, and the government, play a key role in the success of the adaptation strategy.

The future visions of stakeholders play a crucial role in ensuring the sustainability of forested areas and soil health. Establishing a shared vision among different stakeholders is an important step in the protection and management of forests.

Increasing the livelihoods of local people can help alleviate the pressure on forest areas. It is important to implement eco-tourism practices and projects that involve the public as stakeholders, providing them with economic, social, and psychological satisfaction. During the workshop, it was understood that while the impact of technology in financial inclusion is understood in the theoretical sense, combining it with tourism and social inclusion as a whole needs to be understood. Also, the extent to which the impact of technology in tourism remains be addressed. In rural areas with limited infrastructure and technical knowledge, how technology can be made more people-friendly to propagate its use needs to be discussed in-depth.

The national park has a very strict protection status, making it challenging to carry out certain activities within its borders. It may be necessary to loosen or modify this strict protection status to some extent, particularly to facilitate the construction of irrigation canals. Activities like tree planting are currently restricted, and the existing water canal cannot be utilized. Additionally, the lack of water infrastructure requires investments in pipelines, power generators, and other necessary installations, which can be costly. Therefore, effective land allocation for various activities in the NP should be carried out based on the effective participation of main stakeholders during the preparation of planning with innovative sustainable management practices.

By providing adequate information and implementing suitable projects, solutions can be created. With the expected increase in the effects of climate change, there may be a rise in migration from urban areas to rural villages. This migration can lead to soil degradation and inefficiency. Therefore, it is crucial to encourage the use of organic fertilizers over artificial ones, even though the latter may be cheaper. The government should take proactive steps to promote the use of organic fertilizers. Additionally, specific studies should be carried out in NP forest ecosystems to observe the different impacts of climate change on forests and the possible specific management activities that can be scheduled to reduce the future impacts of climate change on forests. Similarly, more studies should be conducted for the future distribution of basic species for NP.

Farmers require support in terms of fertilizers, pesticides, and irrigation. Having an agricultural engineer for every village is necessary. Farmers have expectations of increased productivity in the future, as they believe their soils are currently unproductive. However, there is a concern that agricultural lands may gradually be converted to tourism purposes due to economic considerations. Future land use/land cover change should be estimated in the selected study area and evaluated.

In conclusion, the long-term economic benefits and well-being of local people should be respected. In the national park, a systematic eco-tourism planning and management, and monitoring and control systems for these activities should be established. It is impossible to prevent the pressure of the local people on the natural environment without solving the education and property problems, negative housing conditions, and livelihood problems. Unless the problem of trust, which can be called the main reason for the conflicts between the forest organization and the local people, is eliminated, it is difficult to ensure the participation of the local people in the management of the area.

16.4 References

Capstick SB, Pidgeon NF (2014). Public perception of cold weather events as evidence for and against climate change. Journal of Climate Change 122:695–708. doi:10.1007/s10584-013-1003-1.

Ceylan, S., Özbek, G., Kavak, G., Mert, Y., (2009). "The Role of Identity, Personality, Values and Culture on Bribery Actions with Industrial and Organizational Psychology Perspective", 11th European Congress of Psychology, Oslo, Norway.

Dudu, E., (2021). How Will Climate Change Impact the Protected Area Network in Turkey? Master Thesis, Middle East Technical University, 92 p.

FAO (2013). Climate change guidelines for forest managers. FAO Forestry Paper No. 172. Food and Agriculture Organization of the United Nations, Rome.

Fosso, L. C., &Karahalil, U. (2020). Some important parameters to display the effects of climate change on forest: a case study in Cerle planning unit, Antalya, Turkey.

GDNP, 2023. https://www.tarimorman.gov.tr/DKMP, Accessed on 08.06.2023.

Karahalil, U., Başkent, E.Z., Köse, S., (2015). Integrating Visitor Characteristics and Preferences into Forest Management Plans in Protected Areas: A Case Study in Köprülü Canyon National Park, Journal on Protected Mountain Areas Research and Management, 7(2), 5-17.

Korkmaz, M., (2018). Public awareness and perceptions of climate change: differences in concern about climate change in the West Mediterranean Region of Turkey. Applied Ecology and Environmental Research 16 (4): 4039-4050.

Lindsey, R., Campbell, J., Dukes, J.S., Huntington, T., Mohan, J., Rodenhouse, N., (2012). Changing climate, changing forests: The impacts of climate change on forests of the north-eastern United States and eastern Canada. Gen. Tech. Rep. NRS-99. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 48 p.

Tüfekçioğlu A, Kalay HZ, Küçük M, Kahriman A and Özbayram AK., 2005. Institutions Seen from Insect Damages in Artvin-Hatilla National Park and Their Ecological Causes Triggering it, Spruce Symposium. 142-151.

DPT, 2001. Ormancılık, DevletPlanlamaTeşkilatı 8. 5 YıllıkKalkınmaPlanıÖzelİhtisasKomisyonuRaporu. T.C. DevletPlanlamaTeşkilatıYayını, Ankara.

Taş, İ., 2005. MilliParklardaveCivarındaYaşayanYerelHalkınSorunlarıveÇözümÖnerileri. I. Çevre veOrmancılıkŞurası, 22-24 Mart 2005, Kemer; www.cevreorman.gov.tr

17 Agro-Forestry in DEHESA: Extremadura, Spain

Concha Civantos (concha.civantos@fundecyt-pctex.es), Mayte Gallego (mayte.gallego@fundecyt-pctex.es); Foundation FUNDECYT SCIENTIFIC AND TECHNOLOGICAL PARK OF EXTREMADURA (FUNDECYT-PCTEX)

17.1Regional Information

The DEHESA is a traditional land system (since the Middle Age) of the south-west of the Iberian Peninsula (Extremadura, Andalusia, Alentejo, Castilla-La Mancha, Castilla, and León), a consequence of the clearing of the former Mediterranean forest, that consists mostly of scattered oak trees (holm and cork oaks) combined with annual native pastures that are extensively grazed by sheep, cattle, and Iberian pigs (Figure 17-1). Although grazing is the dominant land use, other land uses such as cereal crops, farming, forestry (cork, charcoal, mushrooms, etc.), hunting, apiculture, ecotourism, and other recreational uses can also be found. In addition, DEHESA represents a significant part of the cultural legacy, traditional food and products, and landscape essence (tourism attraction) of regions such as Extremadura, in which about 60% of its land surface is woody rangelands (DEHESAS) and treeless grasslands (pastizales).

Figure 17-1:Map of the Extremadura, Spain

DEHESA farms are usually privately owned (80% by the owners, 20% rented), large in size (>100 ha), with tree densities ranging between 10 and 60 trees ha-1 depending on their past and present land use intensity, and their animal stocking rates used to be below 0.5 AU ha-1 (AU is the cattle equivalent animal unit) before the adhesion of Spain to the European Union

(EU) in 1986. Livestock is mostly well-adapted local breeds such as retinta cattle, merino sheep, and Iberian pigs that used to be on the farm during the months in which acorns fell to the ground (montanera period). Regardless of livestock, the DEHESA system is highly appreciated for its rich biodiversity and provision of several ecosystem services: clean air, water purification, carbon sequestration, provision of food and fuel, biodiversity conservation, etc (Table 17-1).

Its ecosystem services and cultural legacy have been recognized by the EU and national and regional governments since DEHESA is considered a habitat of special interest and a high-nature-value farming system. DEHESA farms are protected by several regulations. Some farms are also protected by figures of protection such as areas of special conservation (directive habitats), areas of special conservation for birds (directive birds), peri-urban parks of conservation and leisure, sites of scientific interest, private farms of ecological interest (Law 8/98 on nature conservation in Extremadura), and wells of cultural interest, among many others. In addition, DEHESA represents a significant part of the cultural legacy, traditional food and products, and landscape essence (tourism attraction) of regions such as Extremadura, in which about 60% of its land surface is woody rangelands (DEHESAS) and treeless grasslands (pastizales).

Table 17-1:Regional information of Extremadura, Spain

Dominant land use:	Extensive grazing
Secondary land use:	Self-consumption agriculture
Climatic Zone:	Mediterranean
Soil WRB classification:	Leptosol, Cambisol and Regosol
Soil type:	Shallow, sandy-loam textured, slightly acidic and relatively poor in nutrients
Dominant topsoil texture:	Sandy-loam
Soil threat(s):	Erosion, compaction, lack of fertility
Representative regions	

17.2Stakeholders Interaction

The Figure 17-2shows the different categories of stakeholders interacted during the soil needs assessment workshops and interviews in the Extremadura, Spain. The workshop took place at a central location in the region on 13 April 2023.

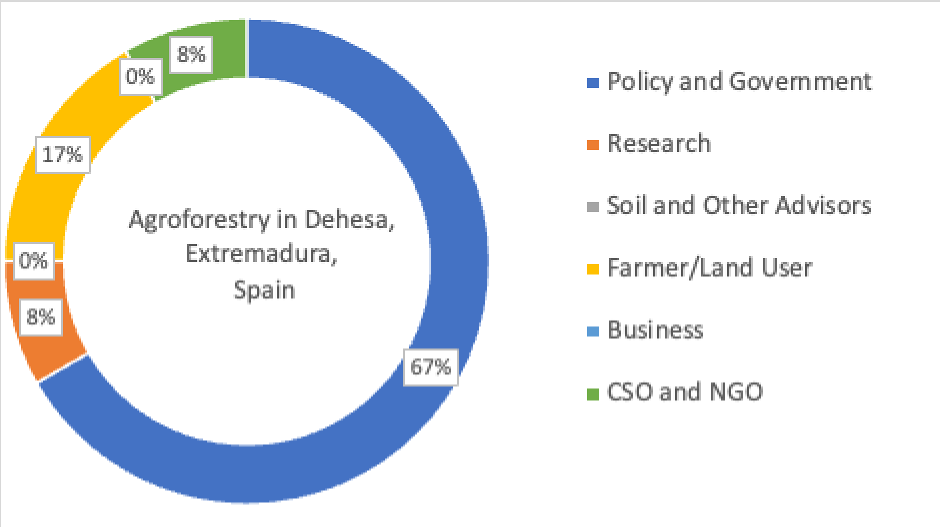


Figure 17-2:Stakeholder interaction in Extremadura, Spain

17.3Soil Needs Assesment

17.3.1Drivers

Biophysical drivers:Regarding environmental drivers in Dehesas, most of them are consequences of **climate change**: drought risk, flood risk, fire risk, frequency of extreme weather, etc. In fact, climate change is starting to be considered the main topic in many recent studies related to this region. The main worry related to climate change is the occurrence of droughts that significantly reduce pasture production and water availability. Hot and dry summers are usual in Mediterranean climate-type areas, as is the occurrence of dry spells.

The current challenge is that scientists and social actors have the perception that summers are becoming drier and warmer, droughts are more frequent, and this development is unstoppable. For instance, in summer 2022, the maximum daily temperature in Extremadura exceeded 40°C almost every day from July 10 to August 15 (data from the official full weather stations of Cáceres and Badajoz cities). This problem is combined with the fact that rainfall events are progressively more intense, which causes hortonian flow and soil erosion. Watering ponds cannot store more water because they receive too much water in a short period of time. For instance, in November and December 2022, the amount of rainfall exceeded 200 mm in 15 days (data from a weather station installed in the pilot farm in La Barrosa, Alburquerque).

The extreme weather is also starting to be a social worry. Extreme events (warm, dry, and cold spells) are more abundant now than in the previous decade. The yearly number of storms has increased from 10 to 12. Electrical storms, in combination with particular weather conditions on windy, dry, and warm days, significantly increase fire risk. For instance, some fires produced in summer 2022 (more than 6,000 ha burned) were caused by the lightening of an electrical storm. For the moment, only abandoned Dehesas have a serious risk of fire.

Another problem related to climate change is the **loss of biodiversity**. Dry rainy seasons, together with the dry conditions of warm summers, restrict the normal development of some vegetation species. Overall, there is a considerable decrease in the water level of the watering ponds where a large number of individuals of amphibians (frogs, tritons, etc.) live and are also the watering point for wild fauna, including hunting animals, birds, insects, etc. several of these issues were described in the Figure 17-3.

As a result of anthropomorphic activity and poor management of the Dehesa, the scrubland typical of this landscape has been uprooted to a large extent, resulting in the degradation of the ecosystem. The scrubland fulfills a vital purpose in the survival of the Dehesa, which is to be an element of adaptation to climate change as forage material and its elimination can break the ecosystem balance, as, among other things, it attracts birds that prevent pests, attract pollinating insects, and is a refuge for small animals.The progressive increase in temperature and reduction in rainfall can also lead to the **death of many trees.** Since the provision of acorns would be an irreplaceable resource, the possibility of introducing fodder scrubs well-adapted to drier conditions could be a transitional solution to mitigate climate effects. It is now being investigated for EU projects such as LIFE SCRUBNET (https://lifescrubsnet.eu/).

Socioeconomic driver/issue: Dehesa farmers are worried mostly by two drivers: **low farm profitability** and a **lack of generational replacement** (information provided in a focus group with farmers). Low farm profitability is causing a high dependence on CAP subsidies. The reason behind that is that the final consumer does not appreciate the real value of meat from extensive farming. Furthermore, they cannot intensify their farms because of the scarcity of natural pastures and the high prices of feed and fertilizers. The regional government is dealing with the creation of four protected geographical indications to label specifically meat, mostly from Dehesas: ternera (cattle <48 months old), vaca (cattle ≥48 months old), lamb, and goat of Extremadura.

The Dehesa system has passed through different stages of social perception over time. Until the 20th century, it was considered an unfair land system in which a single person owned a large farm and the rest of the people worked there with very low salaries (“latifundismo” in Spanish). Nowadays, it is recognized as a key element to avoid the depopulation of rural areas since Extremadura is part of the so-called "empty Spain". It has evolved from being the core of the regional economy, since 60% of the labor force worked in the agriculture sector, to a marginal activity that needs to be subsidized. This **structural change in the economy** is a consequence of the process of social transformation in Spanish society during the 20th century, which implied that many people emigrated from rural areas to cities. This phenomenon of rural exodus of young people is a serious threat for the rural areas in which Dehesa is the dominant landscape.

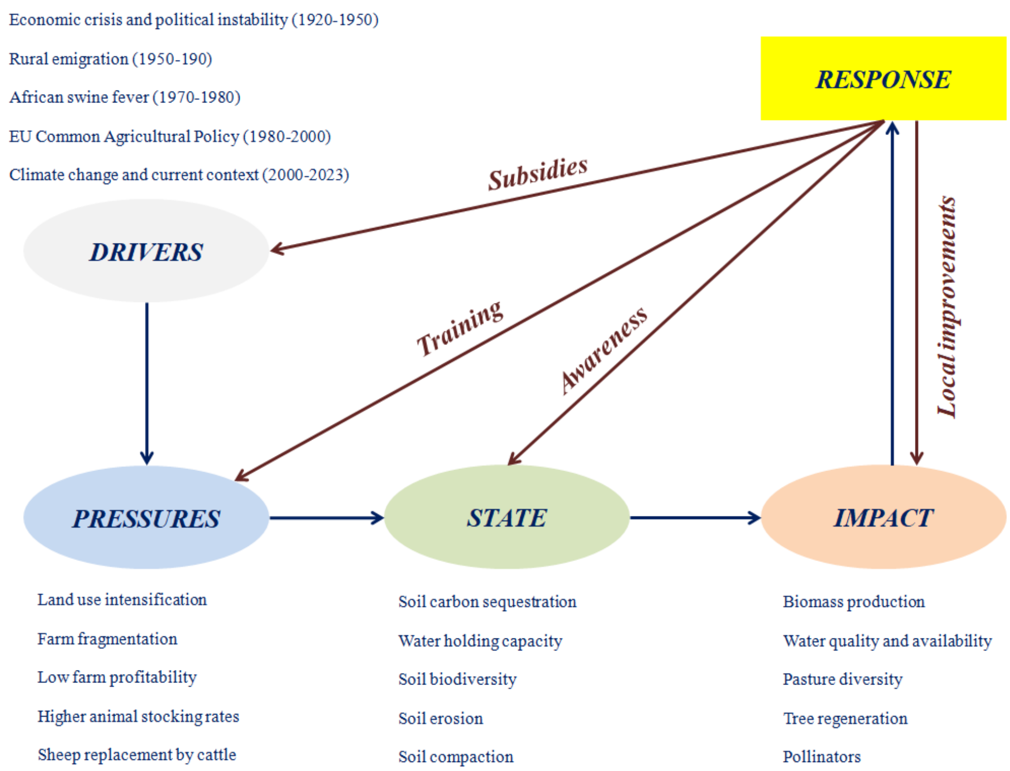


Figure 17-3:Soil management strategy framework in Iberian DEHESA Farms

These rural areas are still undergoing a transformation process beyond the socio-economic changes mentioned above. Although their cultural tissue based on rurality stays stable, significant changes can be observed in urbanization and behavioral habits. On the farms (countryside), except for the house of the owner and paddocks, almost every building has been abandoned: workers' houses, small corrals, etc. In the villages (towns), the number of houses has increased four times, in spite of the fact that the local population has been reduced by about 50%. The urban sprawl of rural areas is due to the boom of second residences built by people that live in other places, but they still preserve a feeling of belonging because they themselves or their ancestors lived in that place. In addition, many people from urban areas like spending their free time in rural areas looking for calm, silence, nature, authenticity, natural food, etc., or because they are lovers of hunting, fishing, hiking, etc. It has caused many Dehesa farms to build tourism facilities to host viitors.

The current society is also facing **structural changes in behaviors** related to food and dietary habits and the awareness of the protection of natural areas. Both things must be interpreted as challenges for Dehesa farmers and their surrounding society since they will represent market opportunities to increase the current value of meat as well as new incomes. Nowadays, society is more sensitive to the quality of the products and their origin, as well as other aspects such as animal welfare, protection of wild fauna and flora, zero emissions, etc. However, the awareness is not enough to support the Dehesa production and make it profitable.

In addition, the environmental rules that come from the EU Natura 2000 network of protected areas and Spanish laws are quite strict and protectionist. We are now in a process in which farmers are starting to learn skills to take advantage of this context and to leave behind the initial idea of not-well-accepted administrative impositions.

With regard to the management of the Dehesa, it is important to highlight the **gradual abandonment of traditional practices such as transhumance and transterminance**, among other reasons, because the proper management of grazing requires specialized labor, which is scarce, increasingly difficult to find, and for which there is no generational replacement. All this is a consequence of the lack of preparation of the owners, many of them not grounded in the territory, of unspecialized managers and operators, and of the loss of popular traditional knowledge.

Finally, it is worth highlighting a **poorly targeted European policy**, such as the Common Agricultural Policy, with subsidies not associated with environmental results, with higher payments for arable land than for permanent pasture, etc. This agricultural policy encourages the mistreatment of the soil in order to maintain a level of direct income through subsidies, resulting in a very demanding regulatory framework that is not justified by the particularities of the system. At the national level, it is important to mention the absence of a master plan for the Dehesa (except in Andalusia), which recognizes its richness and particularities, promotes its sustainability, and allows it to be valued through differentiated quality productions produced under other systems.

17.3.2Pressures

The drivers that have historically influenced the Dehesa system most have been socio-economic. Nowadays, the main unknown is to know how this land system will be able to adapt to much drier climatic conditions. So, the pressures identified here are the consequence of these past and present drivers.

Pressure #1 – The need for cultivation. The continued plowing of soils in the Dehesa is motivated by avoiding the loss of arable land, which allows us to continue charging three times more for that area than for the use of pasture. The soil of Dehesas (shallow and relatively poor in nutrients and organic matter) is not suitable for being cropped regularly. Even the occasional crops can cause significant loss of soil, nutrients, organic carbon, and landscape simplification, as well as moisture and water holding capacity loss. Nowadays, there are some farmers who still think tillage is necessary because this practice was made regularly by their ancestors, and they consider that it reduces soil compaction and increases infiltration capacity.

Pressure #2 – Farm fragmentation as a consequence of internal fencing as a response to the scarcity of shepherds. Farm fragmentation supposedly causes alterations in habitats and biodiversity, thus increasing the occurrence of hotspots of land degradation that did not exist previously (e.g., doors between fences). The current thinking is to fence more parts of the farms with wire, taking advantage of some specific subsidies to modernize agricultural exploitation. It represents real barriers to livestock movement. Electric fencing could be a feasible alternative, but it implies new designs for a traditional semi-natural farming system.

Pressure #3 – Increasing animal stocking rates after the adhesion of Spain to the European Union in 1986 as a consequence of Common Agricultural Policy subsidies that paid for the number of livestock heads. It has provoked land degradation processes in cascade: erosion > compaction > lack of fertility > decline of pasture production > loss of biodiversity > death of many trees > lack of tree regeneration. To solve these problems, society's discussion is about optimum stocking rates and smart grazing, i.e., new forms of pastoralism that do not produce land degradation. Nevertheless, the reality is that soil degradation is still a common feature in many parts of the farms, and it means a remarkable total amount of degraded land surface at a regional scale.

Pressure #4 – The progressive replacement of sheep by cattle, since this latter cattle management is easy to manage. It is also a current consequence of the scarcity of workers in the Dehesa system. Regional authorities should invest more money in training people in livestock management, including traditional knowledge for this kind of job. Otherwise, the total number of sheep, the best-adapted species, can be dramatically reduced.

Pressure #5 – Lack of tree regeneration. The increasing intensity of land use as well as the aging of trees, combined with diseases caused by pathogens (such as Phytoctora cinnamomi), have provoked the deaths of several trees. The absence of tree regeneration is also influenced by the application of the Grassland Subsidy Coefficient. The general accelerated loss of trees reduces their effect as shock absorbers and soil protectors. It can only be overcome with tree reforestation and excluding some areas from grazing for at least 10–15 years. Reforestations are often welcome because farmers can obtain subsidies to compensate for income losses from grazing. However, the sacrifice, which would mean a permanent rotational exclusion system of 5% of the land surface, is not well accepted yet by farmers. In spite of this, farmers recognize that tree regeneration is one of the most serious problems they are facing.

Pressure #6 – Land abandonment as a consequence of low farm profitability and the lack of generational relay in many farms. This process will presumably cause a cascade of undesired effects: undesired matorralization (shrub encroachment) > lack of productivity and market value of the farm > proliferation of hunting animals that can transmit diseases to livestock and provoke damages in agriculture crops, road accidents, etc. > land simplification > higher wildfire risk. Nowadays, many Dehesa farms have been fully or partially abandoned, or they are being undergrazed.

Pressure #7 – Changes in land management as a consequence of new social habits and also the de-professionalization of the sector and managerial absenteeism. There are some risks that many farms can change their current land management based on extensive livestock husbandry through other forms such as hunting, ecotourism, leisure activities, land abandonment, conversion into agriculture, solar orchards, etc. This kind of change could mean significant changes in many matters, including soil properties. The lack of a labor force can lead to remarkable farm fragmentation and excessive use of machinery and external feed.

17.3.3State

The current state of Dehesas regarding soil health is not satisfactory yet because they are overcoming former processes of land use intensification in parallel with current livestock mismanagement on many farms. Although their normal edaphic conditions are not so exigent: shallow soils, poor in nutrients and organic matter, etc., the optimum conditions could only be reached when every farm has a reasonable tree density (ca. 30 trees ha-1). Since tree litter is a key issue for nutrient cycling and soil fertility, practices such as tillage and pruning should be stopped or rethought, and smart grazing should be a common feature for every farm. This is the only way to avoid land degradation in the form of soil erosion, compaction, nutrient washing, decline of fertility, reduction of pasture production, and lack of tree regeneration.

State #1 – Soil erosion: The soil loss rates in Dehesas are usually below 1 t ha-1 y-1, except in some specific cases in which cultivation of cereal has been needed or animal stocking rates have been above the carrying capacity of the site. Cereal crops provoke sheet and rill erosion, and it is the main driver of gully erosion. Regarding livestock mismanagement (>0.5 AU ha-1 in dry years, >1.0 AU ha-1 in normal years, problems in the rotational system, etc.), it provokes initially large patches of bare soil that lead to soil erosion but overall lead to nutrients washing as well as litter removal beneath the trees. Although soil erosion rates are not relatively high in comparison to other systems, the loss of 1 cm of soil in this kind of environment can mean a decline of 20% in the total soil nutrient content and a loss of 5% of the soil depth due to its shallowness.

State #2 – Soil compaction is a problem that is evident in certain parts of many farms. Normally, it happens in areas where livestock spend a lot of time, and it is a consequence and cause of soil erosion at the same time. It is normally evident in animal paths, in areas where soils are saturated in winter, near watering ponds, fences, doors, paddocks, etc. Its worst consequence is the reduction (sometimes 100%) of pasture production in these areas, and in cases where pasture production still happens, the quality of pastures is usually much lower. Sometimes farmers need to crop this area to avoid crusting, which provokes soil erosion and the release of carbon.

State #3 - Loss of nutrients and organic matter: Soil erosion and compaction in Dehesas lead to losses of nutrients due to their concentration, which is mainly concentrated in the top 5 cm. A remarkable amount of nutrients can be lost in a single event of rainfall. It is still possible to recover optimum levels of nutrients and organic matter lost due to the overall cultivation of the 20th century and heavy grazing in recent decades. They have released soil organic carbon, induced soil erosion, and prevented nutrient cycling as a consequence of the removal of litter usually accumulated beneath the trees. This problem can only be avoided by keeping soils covered by grasses at the beginning of the rainy season (October) through smart grazing.

State #4 – Soil quality and land degradation: Recent research suggests that Dehesas has not reached optimum soil quality yet. In fact, 20% of farms are still assessed as strongly degraded. So, efforts must still be made by every stakeholder in the right way to reduce land degradation effects.

17.3.4Impacts

The impacts suffered by the Dehesa system are a consequence of socio-economic drivers that happened overall during the 20th century and in recent decades. These drivers have imposed a series of pressures on the system that have initially had negative impacts on soil quality and, after that, on the whole land system. Some of them are listed below.

Impact #1 – Reduction of biomass production (including pastures and trees): All the land degradation processes mentioned above act in cascade, provoking a serious deterioration of the Dehesa system that, under normal circumstances, can produce > 2,000 kg of dry matter or annual natural pastures per hectare. These pastures are of high quality, have a high nutritional value, and are palatable for livestock. However, soil degradation processes also lead to tree deterioration through multiple mechanisms. Poor management of vegetation cover increases the risk of fires. Pasture production can be reduced by as much as 25% on average in a normal year due to moderate land degradation. The death of trees is significantly higher in degraded areas than in well-managed ones.

Impact #2 – Soil erosion: The loss of the biomass that acts as a protective soil cover increases soil erosion. Soil erosion results in increased soil temperatures and compaction, deterioration of the soil water cycle, deficiency in CO2 sequestration, vulnerability to flooding and landslides, and reduced resistance to soil diseases, with consequent loss of biodiversity and reduction of productivity.

Impact #3 – Less water quality and availability: Water in Dehesas is a scarce resource that is normally stored in ponds during the summer. Land degradation processes, in combination with the effects of climate change, are causing a significant reduction in the total amount of water that ponds can store due to the increase in evaporation and the loss of water holding capacity caused by compaction. In addition, water quality is usually lower in these degraded areas.

Impact #4 – Loss of biodiversity: Land use intensification and land abandonment are two coexisting processes that are provoking a landscape simplification and reducing biodiversity at many scales: pedofauna, pastures, pollinators, birds, amphibians that live in the watering ponds, etc. Nevertheless, land abandonment must be interpreted as a necessary step in the ecological succession to recover soil quality and vegetation lost during former processes of intensification. The challenge would be to increase biodiversity while farm profitability is maintained.

Impact #5 – Increase in the external dependence of the farms, which is reducing their profitability considerably: Land degradation processes within the farm cause serious losses in terms of pasture and acorn production. It means farmers need to buy external inputs to feed their livestock or make unsustainable decisions, such as cropping for hay. It implies a significant cost since this kind of input is quite expensive since the COVID-19 pandemic, the War of Ukraine, and the current period of price inflation that has increased the price of straw five times, for instance.

Impact #6 – Loss of reputation: Land use intensification can cause a loss of reputation for almost all organic products, such as cattle, pork, and lamb meat, that Dehesas produce. Nevertheless, a pending task of the current society is to reach a fair price for the meat produced in Dehesas since it is the best alternative to landless production. Some measures are still being carried out, but it is necessary to influence the final consumers. Short-chain sales of products like cattle meat are not seen as a feasible option by many farmers since it would mean the design of slaughterhouse facilities on their farms. It needs a significant investment and compliance with many biosafety rules.

17.3.5Response

Response #1 – Zero tillage: The most worrying losses of soil and organic carbon have been provoked by certain contexts in which farmers must cultivate. This must be avoided or reduced in the future.

Response #2 – Smart grazing: An inadequate animal stocking rate or livestock mismanagement have provoked significant problems of soil compaction, erosion, and nutrient washing. Farmers must be trained to avoid that through intelligent, sustainable, and regenerative grazing with seasonally appropriate stocking rates, which are reduced in periods of climatic alert. A holistic approach to livestock management would be desirable. The use of traditional breeds as well as the recovery of ancestral practices such as transhumance could be desirable for the environment, although they are not well accepted by many farmers yet. Most of them consider them unprofitable, old-fashioned practices.

Response #3 – Soil protection: In degraded areas with a significant presence of gullies, it is suggested to construct check-dams to avoid soil losses during torrential events, which are becoming more frequent.

Response #4 – Tree regeneration: Trees are keys to producing acorn and also to catching organic carbon via photosynthesis. They are also the main source of nutrients in the soil, along with animal excreta, and are a priority for sustaining pastures. It is necessary to implement regeneration and afforestation techniques with support irrigation, as well as to impose temporary rotational exclusions (10 years) for livestock of at least 5% of the farm to promote tree regeneration. Protecting natural regrowth is seen as a much smarter solution than reforestation by many farmers.

Response #5 – Ecosystem regeneration: In order to restore the balance lost in the Dehesa ecosystem, and in addition to improving the tree stratum, it is necessary to increase the diversification of the ligneous stratum and forage species. This could be achieved by planting forage brushwood in hedges and by improving pastures through direct sowing of legume vegetables. These pastures have to be protected through proper livestock management, as mentioned above. Other measures would be aimed at mitigating the consequences of climate change: the construction of infrastructures that reduce the effects of erosion, such as the placement of gabion walls and nesting boxes; and strategies for rainwater accumulation, such as more efficient pond management.

Response #6 – Fair prices: The lack of profitability on many farms is a result of the relatively low price that farmers receive for their products. In fact, it is one of the reasons for land intensification and abandonment. In order to have a fair price for these products, it is necessary to promote and certify the value of livestock production in the Dehesa through quality marks, which would differentiate them from conventional models and generate an economy without having to resort to intensification. For this reason, authorities must promote good marketing of this meat, and farmers must find new sales channels, such as direct sales and gourmet markets.

Response 7# – Policies' improvement: Regional and national policies and aids adapted to the reality of the Dehesa are needed, such as a Master Plan for the Dehesa as developed in the Andalusia region and policies aimed at conservation and production needs that may pay for environmental results (carbon sequestration, improved biodiversity, improved functioning of ecosystem processes, etc.) and/or offer tax benefits to those who are doing things right. Also, awareness-raising policies on the importance of environmental values and ecosystem services are convenient, which enhances the value of Dehesa and its products for the end consumer.

Response #8 - New cooperative/multi-actor working methodologies: The use of new collaborative, multidisciplinary, and multilevel working methodologies, such as the Living Lab, is a solution that adapts perfectly to the needs of the Dehesa. A Living Lab for the Dehesa could cover the whole Extremadura territory with several lighthouses made up of farms with natural conditions (soil, vegetation, livestock) representative of the Dehesa. It should have a repertoire of infrastructures made up of technological and university centers, laboratories, and farms, offering a real possibility of knowledge exchange and joint use of equipment and facilities, with the participation of the public administrations involved in policy development and the management of any procedure or aid related to Dehesa, as well as the rest of the actors involved.

17.4Conclusions

Dehesa is currently in a double process of facing, on the one hand, a period of recovery and valorization by a significant part of society and political actors and, on the other hand, the persistence of mismanagement practices that provoke soil degradation and a bad reputation. New threats induced by the effects of climate change and the loss of rural populations are threatening the current scenario. The use of new technologies and new forms of agriculture and pastoralism seems to be essential for the survival and sustainability of this ancestral land system.

Farmers need to have extra income beyond subsidies to maintain the profitability of their farms, but this extra money cannot come from subsidies forever. So, farms must promote other lucrative and profitable activities such as ecotourism, leisure, beehives, forestry uses, hunting, fishing, etc. that can be combined with the dominant land use as livestock husbandry. They need to find new markets in which their products can be sold at the fair price that they deserve since they are almost organic.

The use of new high-tech technologies as sensors, apps for rational grazing, apps to take care of animal welfare, etc. seems to be feasible solutions to face challenges such as the scarcity of skilled workers and low farm profitability, even to connect farmers and end-users. Everything will pose a paramount challenge for the upcoming society. Anyway, this ancestral system will only be able to survive if soil quality is at its optimum level, i.e., land degradation processes are negligible and trees and pastures grow in the best possible conditions.

Significant advances have been made regarding the design of a living lab. There are agents from different levels already involved, such as farms, villages, universities, technological centers, citizens, etc.

17.5 References

Acosta Naranjo, R. (2002) Los entramados de la diversidad: Antropología social de la dehesa. Badajoz: Diputación de Badajoz.

Alfonso-Torreño, A., Gómez-Gutiérrez, Á., Schnabel, S., Contador, J.F.L., de Sanjosé Blasco, J.J., Fernández, M.S. (2019) sUAS, SfM-MVS photogrammetry and a topographic algorithm method to quantify the volume of sediments retained in check-dams. Science of the Total Environment 678: 369-382.

Bajouco, R., Penedos, C., Velez, J., Velez, S., Alexandre, C. (2022) The Iberian Montado/Dehesa in face of climate change: Soil effects (bulk density and hydraulic conductivity). Revista de Ciências Agrárias 45: 202-205.

Barrena-González, J., Lozano-Parra, J., Alfonso-Torreño, A., Lozano-Fondón, C., Abdennour, M.A., Cerdà, A., Pulido-Fernández, M. (2020a) Soil erosion in Mediterranean chestnut tree plantations at risk due to climate change and land abandonment. Central European Forestry Journal 66: 85-96.

Barrena-González, J., Rodrigo-Comino, J., Gyasi-Agyei, Y., Pulido Fernández, M., Cerdà, A. (2020b) Applying the RUSLE and ISUM in the Tierra de Barros Vineyards (Extremadura, Spain) to estimate soil mobilisation rates. Land 9: 93.

Clemente Ramos, J. (2012). Ocupación del espacio y formas de explotación: Dehesas y adehesamiento en Extremadura (c.1250 - c.1450). In: García Fitz, F., Jiménez Alcázar, J. F. La historia peninsular en los espacios de frontera: Las "extremaduras históricas" y la "transierra"(siglos XI-XV). Sociedad Española de Estudios Medievales, Editum, Murcia. pp. 253-277.

Correa-González, J., López-Díez, A., Díaz-Pacheco, J., Martín-Raya, N. (2023) Climate Change and Sustainability in Spanish Classrooms: State of the Art and Didactic Proposal. Social Sciences 12: 108.

Díaz-Guardamino Uribe, M. (2008) Iconical signs, indexical relations: Bronze Age stelae and statue-menhirs in the Iberian Peninsula. Journal of Iberian Archaeology 11: 31-46.

Escribano, M., Gaspar, P., Mesias, F. (2020) Creating market opportunities in rural areas through the development of a brand that conveys sustainable and environmental values. Journal of Rural Studies 75: 206-215.

Escribano, M., Horrillo, A., Mesías, F.J. (2022) Greenhouse gas emissions and carbon sequestration in organic dehesa livestock farms. Does technical-economic management matters? Journal of Cleaner Production 372: 133779.

Fagerholm, N., Oteros-Rozas, E., Raymond, C.M., Torralba, M., Moreno, G., Plieninger, T. (2016) Assessing linkages between ecosystem services, land-use and well-being in an agroforestry landscape using public participation GIS. Applied Geography 74: 30-46.

Fernández-Ferrín, P., Bande, B., Galán-Ladero, M.M., Martín-Consuegra, D., Díaz, E., Castro-González, S. (2019) Geographical indication food products and ethnocentric tendencies: The importance of proximity, tradition, and ethnicity. Journal of cleaner production 241: 118210.

Fernández-Habas, J., Fernández-Rebollo, P., Gallardo-Cobos, R., Vanwalleghem, T., Sánchez-Zamora, P. (2022) A Farmer's Perspective on the Relevance of Grassland-Related Innovations in Mediterranean Dehesa Systems. Forests 13: 1182.

García Marín, R., Mateos Rodríguez, A.B. (2010). El clima de Extremadura. In: Schnabel, S., Lavado Contador, J. F., Gómez Gutiérrez, Á., García Marín, R. Aportaciones a la Geografía Física de Extremadura. Fundicotex, Cáceres. pp. 25-52.

García Marín, R., Schnabel, S., Lozano Parra, J., Pulido Fernández, M. (2012) Evolución de las precipitaciones en el suroeste de la Península Ibérica (Extremadura). Nimbus: Revista de climatología, meteorología y paisaje 29: 277-288.

García Pérez, J. (2002) Ascertaining landscape perceptions and preferences with pair-wise photographs: Planning rural tourism in Extremadura, Spain. Landscape Research 27: 297-308.

González Barahona, P., Barrena González, J., Lagar Timón, D., Lozano Parra, J., Pulido Fernández, M. (2020) Identification of tourist resources for the design of thematic routes in the natural corridor of the Armorican Arch of Cáceres (Extremadura, SW Spain). International Journal of Geoheritage and Parks 9: 69-81.

Gonzalo Langa, J. (2011). El impacto de la aplicación de la PAC en las producciones ganaderas de la Dehesa (1986-2010). In: Coleto Martínez, J. M., de Muslera Pardo, E., González Blanco, R., Pulido García, F. La agricultura y la ganadería extremeñas: Informe 2010. Caja de Ahorros de Badajoz: pp. 181-196.

Gurría Gascón, J.L., Nieto Masot, A., Hernández Carretero, A.M. (2009) Población, actividad y paro en la segunda mitad del siglo XX en Extremadura. Tejuelo 6: 82-103.

Hidalgo-Galvez, M.D., Barkaoui, K., Volaire, F., Matías, L., Cambrollé, J., Fernández-Rebollo, P., Carbonero, M.D., Pérez-Ramos, I.M. (2022) Can trees buffer the impact of climate change on pasture production and digestibility of Mediterranean dehesas? Science of the Total Environment 835: 155535.

Hidalgo-Galvez, M.D., Matías, L., Cambrollé, J., Gutiérrez, E., Pérez-Ramos, I.M. (2023) Impact of climate change on pasture quality in Mediterranean dehesas subjected to different grazing histories. Plant and Soil 1-19.

Iglesias, E., Báez, K., Diaz-Ambrona, C.H. (2016) Assessing drought risk in Mediterranean Dehesa grazing lands. Agricultural Systems 149: 65-74.

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. Vienna, Austria: International Union of Soil Sciences (IUSS).

Jiménez, V., Sánchez, J.-M., Rengifo, J.-I. (2019) A new residential role for the rural environment in extremadura, Spain. Sustainability 11: 435.

Kampherbeek, E.W., Webb, L.E., Reynolds, B.J., Sistla, S.A., Horney, M.R., Ripoll-Bosch, R., Dubowsky, J.P., McFarlane, Z.D. (2022) A Preliminary Investigation of the Effect of Solar Panels and Rotation Frequency on the Grazing Behavior of Sheep (Ovis Aries) Grazing Dormant Pasture. Applied Animal Behaviour Science 105799.

Lavado Contador, J.F., Pulido Fernández, M., Schnabel, S., Herguido Sevillano, E. (2015). Fragmentation of SW Iberian rangeland farms as assessed from fencing and changes in livestock management. Effects on soil degradation. In: Hakan Alphan, M. A., Baylan, E., Karadeniz, N. Proceedings of the International Congress on Landscape Ecology, 23-25 October 2014. IALE, Antalya, Turkey. pp. 183-192.

Lavado Contador, J.F., Schnabel, S., Trenado Ordóñez, R. (2000) La dehesa: Estado actual de la cuestión. Clío: History and History Teaching 17: 3.

Llorent-Bedmar, V., Cobano-Delgado Palma, V.C., Navarro-Granados, M. (2021) The rural exodus of young people from empty Spain. Socio-educational aspects. Journal of Rural Studies 82: 303-314.

Lopes, C., Gallego, J.R., Leitão, J. (2022) Los productos de calidad y el desarrollo de actividades turísticas:: el caso de Extremadura (España) y Região Centro (Portugal). Finisterra 57: 39-63.

López Rodríguez, E. (2020) Impacto social y percepción de riesgos naturales en Extremadura. Cáceres. Tesis Doctoral en Geografía: Universidad de Extremadura.

Low, G., Dalhaus, T., Meuwissen, M.P. (2023) Mixed farming and agroforestry systems: A systematic review on value chain implications. Agricultural Systems 206: 103606.

Marín-Comitre, U., Gómez-Gutiérrez, Á., Lavado-Contador, F., Sánchez-Fernández, M., Alfonso-Torreño, A. (2021) Using geomatic techniques to estimate volume–area relationships of watering ponds. ISPRS International Journal of Geo-Information 10: 502.

Marín-Comitre, U., Schnabel, S., Barrena-González, J., Pulido-Fernández, M. (2022) Pond water quality for livestock in southwestern Iberian rangelands. Rangeland Ecology & Management 83: 31-40.

Marín-Comitre, U., Schnabel, S., Pulido-Fernández, M. (2020) Hydrological characterization of watering ponds in rangeland farms in the Southwest Iberian Peninsula. Water 12: 1038.

Marsden, C., Martin-Chave, A., Cortet, J., Hedde, M., Capowiez, Y. (2020) How agroforestry systems influence soil fauna and their functions-a review. Plant and Soil 453: 29-44.

Martín-Delgado, L.-M., Jiménez-Barrado, V., Sánchez-Martín, J.-M. (2022) Sustainable Hunting as a Tourism Product in Dehesa Areas in Extremadura (Spain). Sustainability 14: 10288.

Martínez García, E. (2004). Yuxtaposición de dominios en las dehesas boyales de Extremadura. Cáceres, Universidad de Extremadura.

Martínez Puche, A., Martínez Puche, S., García Delgado, F.J., Amat Montesinos, X. (2022) The representation of the rural exodus in Spanish cinema (1900-2020): Evolution, causes and territorial consequences. Investigaciones Geográficas (España) 77: 79-101.

Moreno, G., Herrera, P.M., Guimarães, M.H., Ferraz-de-Oliveira, I. (2021). Time for collective actions: Innovations for silvopastoral territories. Governance for Mediterranean Silvopastoral Systems. Routledge: pp. 245-259.

Muñoz-Rojas, J., Guzmán-Álvarez, J.R., Loupa-Ramos, I. (2021). The complexity of public policies in Iberian montados and dehesas. Governance for Mediterranean Silvopastoral Systems. Routledge: pp. 169-188.

Navarro-Rosales, F., Fernández-Habas, J., Reyna-Bowen, L., Gómez, J.A., Fernández-Rebollo, P. (2023) Subsoiling for planting trees in dehesa system: long-term effects on soil organic carbon. Agroforestry Systems

Olea, L., San Miguel-Ayanz, A. (2006). The Spanish dehesa. A traditional Mediterranean silvopastoral system linking production and nature conservation. 21st General Meeting of the European Grassland Federation.

Olea Márquez de Prado, L. (2011). La dehesa: reflexiones de un ganadero. Pastos, paisajes culturales entre tradición y nuevos paradigmas del siglo XXI, Sociedad Española para el Estudio de los Pastos.

Peco, B., Oñate, J.J., Requena, S. (2001) Dehesa grasslands: natural values, threats and agri-environmental measures in Spain. Recognising European Pastoral Farming Systems and Understanding their Ecology. EFNCP 23: 37-44.

Plieninger, T. (2006) Habitat loss, fragmentation, and alteration - Quantifying the impact of land-use changes on a Spanish dehesa landscape by use of aerial photography and GIS. Landscape Ecology 21: 91-105.

Plieninger, T., Flinzberger, L., Hetman, M., Horstmannshoff, I., Reinhard-Kolempas, M., Topp, E., Moreno, G., Huntsinger, L. (2021) Dehesas as high nature value farming systems: a social-ecological synthesis of drivers, pressures, state, impacts, and responses. Ecology and Society 26: 23.

Pulido-Fernández, M., Schnabel, S., Lavado-Contador, J.F., Miralles Mellado, I., Ortega Pérez, R. (2013) Soil organic matter of Iberian open woodland rangelands as influenced by vegetation cover and land management. Catena 109: 13-24.

Pulido, F., Picardo, Á. (2010) Libro verde de la dehesa. Virtual book: Junta de Castilla y León, SECF, SEEP, AEET, SEO.

Pulido Fernández, M. (2014) Indicadores de calidad del suelo en áreas de pastoreo. Tesis Doctoral. Cáceres: Universidad de Extremadura.

Pulido Fernández, M., Stavi, I., Barrena González, J. (2022) Is land abandonment remarkable in the so-called Empty Spain? Investigaciones Geográficas 63: 77-88.

Pulido, M., Alfonso-Torreño, A., Barrena-González, J., Robina-Ramírez, R., Abdennour, M.A. (2020) Identifying problems in watering ponds with different purposes. Environments 7: 63.

Pulido, M., Schnabel, S., Lavado Contador, J.F., Lozano-Parra, J., Gómez-Gutiérrez, Á. (2017) Selecting indicators for assessing soil quality and degradation in rangelands of Extremadura (SW Spain). Ecological Indicators 74: 49-61.

Pulido, M., Schnabel, S., Lavado Contador, J.F., Lozano-Parra, J., González, F. (2018) The impact of heavy grazing on soil quality and pasture production in rangelands of SW Spain. Land Degradation & Development 29: 219-230.

Rengifo Gallego, J.I., Sánchez Martín, J.M. (2016) Caza y espacios naturales protegidos en Extremadura. Investigaciones Geográficas 65: 57-73.

Reyes-Palomo, C., Aguilera, E., Llorente, M., Díaz-Gaona, C., Moreno, G., Rodríguez-Estévez, V. (2022) Carbon sequestration offsets a large share of GHG emissions in dehesa cattle production. Journal of Cleaner Production 358: 131918.

Reyna-Bowen, L., Fernandez-Rebollo, P., Fernández-Habas, J., Gomez, J.A. (2020) The influence of tree and soil management on soil organic carbon stock and pools in dehesa systems. Catena 190: 104511.

Rodrigo-Comino, J., Barrena-González, J., Pulido-Fernández, M., Cerdá, A. (2019) Estimating non-sustainable soil erosion rates in the Tierra de Barros vineyards (Extremadura, Spain) using an ISUM update. Applied Sciences 9: 3317.

Rodríguez-Rojo, M.P., Roig, S., López-Carrasco, C., Redondo García, M.M., Sánchez-Mata, D. (2022) Which Factors Favour Biodiversity in Iberian Dehesas? Sustainability 14: 2345.

Rodríguez Rigueiro, F.J. (2021) Agroforestry Innovation and CAP, impact on climate change, bio-economy and circular economy. Santiago: Universidade de Santiago de Compostela.

Sánchez-Martín, J.-M., Blas-Morato, R., Rengifo-Gallego, J.-I. (2019) The dehesas of extremadura, Spain: A potential for socio-economic development based on agritourism activities. Forests 10: 620.

Sánchez-Oro Sánchez, M. (2020) Back-Home tourism in Extremadura, Spain: Spending patterns and motivation. Cuadernos de Turismo 46: 71-91.

Sánchez Martín, J.M., Rengifo Gallego, J.I., Martín Delgado, L.M. (2018) Tourist mobility at the destination toward protected areas: The case-study of extremadura. Sustainability 10: 4853.

Schnabel, S. (1997) Soil erosion and runoff production in a small watershed under silvo-pastoral landuse (dehesas) in Extremadura, Spain. Logroño: Geoforma Ediciones.

Tárrega, R., Calvo, L., Taboada, Á., García-Tejero, S., Marcos, E. (2009) Abandonment and management in Spanish dehesa systems: effects on soil features and plant species richness and composition. Forest ecology and management 257: 731-738.

Uribe, C., Inclán, R., Hernando, L., Román, M., Clavero, M., Roig, S., Van Miegroet, H. (2015) Grazing, tilling and canopy effects on carbon dioxide fluxes in a Spanish dehesa. Agroforestry Systems 89: 305-318.

Wolpert, F., Quintas-Soriano, C., Pulido, F., Huntsinger, L., Plieninger, T. (2022) Collaborative agroforestry to mitigate wildfires in Extremadura, Spain: land manager motivations and perceptions of outcomes, benefits, and policy needs. Agroforestry Systems 96: 1135-1149.

18 Alpine Tourism: Lautaret-Oisans Alpine region, France

Lisa Viry (Acta), Flavien Poinçot (Acta)

18.1 Regional Information

The Lautaret-Oisans LTSER platform, located in the French Alps, covers an area of 15,000 hectares, mainly in the North Alps region (Figure 18-1 and Figure 18-2). The platform aims to improve the coordination of research projects carried out in the area. The spatial organization of Lautaret-Oisans depends mainly on tourist activities and agricultural practices. Lautaret-Oisans is a popular tourist destination. It is crossed by the Grandes Alpes ski route and includes several major winter sports resorts (Alpe d'Huez, les Deux-Alpes, Serre-Chevalier, la Toussuire, Valloire). The high mountains are also a popular area for sporting activities, particularly in the Parc des Ecrins. The area has maintained a mountain agriculture based on cattle and sheep farming; the vast areas of mountain pasture are used by both transhumant and local herds. All these activities exert pressure on the soil, leading to its artificialization and destruction, localized erosion, and compaction.

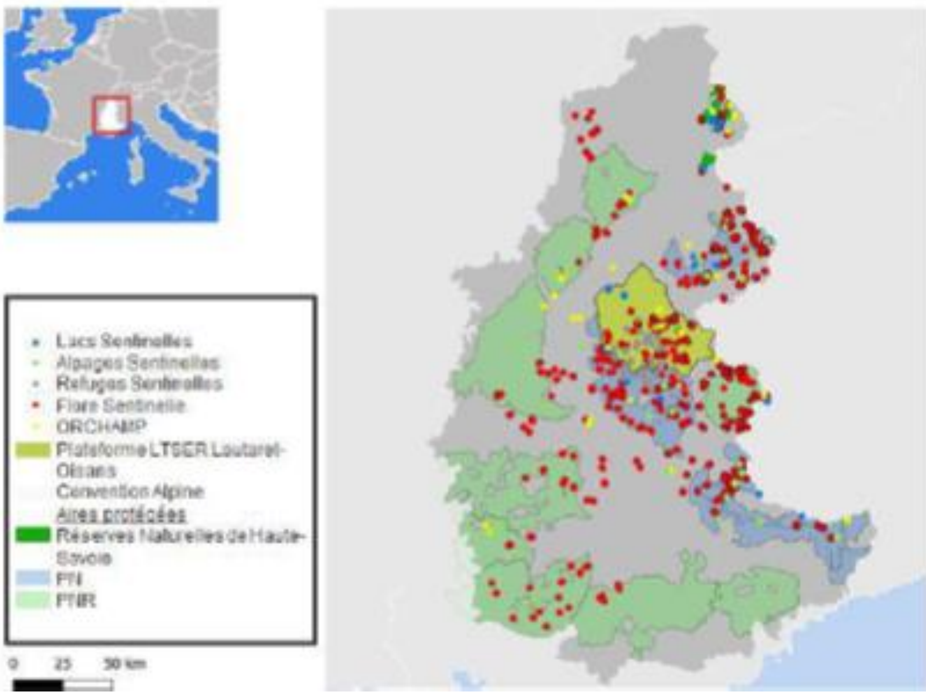


Figure 18-1:The Lautaret-Oisans platform in France

The region has mountainous and continental climates with Mediterranean influences. However, the effects of climate change are disrupting the climate and forcing the region's stakeholders to consider reconfiguring their activities (Table 18-1). While the local economy depends mainly on winter sports, the reduction in snow cover is questioning the economic survival of low-altitude winter sports resorts. The high-altitude resorts want to maintain their development, even if they try to diversify their activities. In this context, the introduction into French law of a target of no net land take by 2050 is seen as a challenge for local stakeholders.

Figure 18-2:Platform LTSER Lautaret-Oisans platform, France

Table 18-1:Regional Information of The Lautaret-Oisans platform, France

Name	**Lautaret-Oisans**
NUTS2 Code	FRK2
Dominant land use	Natural, agriculture (pastoral)
Secondary land use	Recreative (skiing, biking, etc.)
Climatic Zone	Mountain climate / continental
Soil WRB classification	Cambisol, Colluvic Regosols, Hyperskeletic Leptosols
Soil texture	Limestone, silt, acid and calcareous stones / glaciers
Soil threats	Climate change (erosion, changes in the cryosphere and water resources, increase in climatic hazards and risks in the high mountains, increase and elevation of wooded areas, artificialization of valley bottoms, greening) Mass tourism (urbanization, biodiversity degradation, erosion)
Representative	Alpine regions, other mountain regions to a lesser extent

18.2Stakeholder Interaction

Stakeholders were identified through literature searches and early interviews. The objective was to ensure that the stakeholders interviewed were representative of the various economic interests, issues, and uses of mountain land in Lautaret-Oisans. The Soil Needs Assessment workshop took place on May 10, 2023 in Grenoble, France. 8 local stakeholders participated in this event. 13 interviews with local stakeholders were organized between January and May 2023, one involving two stakeholders. In total, 16 stakeholders from 15 organizations were involved, either during the workshop or interviews (Figure 18-3:Stakeholder interaction in Rhone-Alpes, France). Some stakeholders, although mainly involved as representatives for one category, also have activities in other categories (e.g., some stakeholders from research also have activities related to higher education; some associations gather stakeholders from different categories) and were therefore able to share input related to these activities.

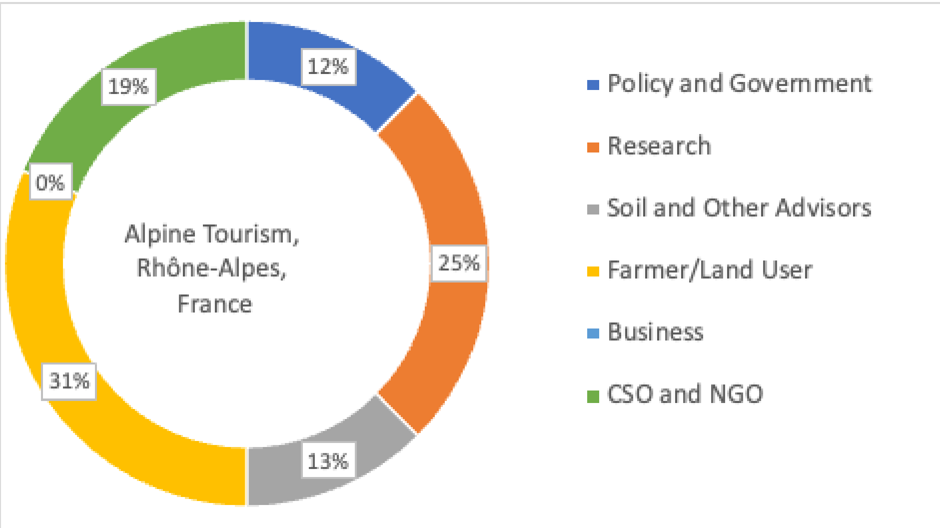


Figure 18-3:Stakeholder interaction in Rhone-Alpes, France

18.3Soil Needs Assessment

18.3.1Drivers

Biophysical drivers: Climate change is the main factor driving change in Lautaret-Oisans. Its effects are unanimously acknowledged by the stakeholders interviewed. The mountains can be seen as "sentinels" of climate change, as the **rise in temperature** is, on average, more important in the mountains than in the surrounding area (Beniston et al., 1997; Pepin et al., 2022). In 2022, the rise in global temperatures is estimated at +1.15°C compared with the pre-industrial period and +2.37°C in the French Alps.

Rising temperatures are causing glaciers to retreat, and glaciers could lose from 85% (+1.5°C scenario) to 99% (+4°C scenario) of their mass by 2100 (Rounce et al., 2023). Observations show that, over the period 1999–2016, the Glacier Blanc, located in the Lautaret-Oisans platform, has lost a cumulative mass of -11.53 m of water equivalent, which corresponds to an average loss of almost 13 m of ice over its entire surface (GREC-SUD, 2018). A new ecosystem appears in proglacial margins (Khedim et al., 2020), but little is known about the links between plants, microorganisms, and soil formation in these areas.

The **decline in snow cover** is also already visible. For the Northern Alps as a whole, the **Agence Alpine des Territoires** (Agate territoires, 2022) estimates a 22% difference in snow cover between December 2021 and the average snow cover during the 1961–1990 period. Regardless of the emissions scenario, the average winter snow depth at low altitudes in 2050 is foreseen to fall by a further 10% to 40% compared with 1986–2005 (IPCC, 2019).

A greening phenomenon can be observed in the Lautaret-Oisans, with the expansion of the forest into the sub-alpine zone, the arrival of lowland species and invasive species, and the advancement and extension of the growing seasons. Between 2000 and 2015, 56% of the Écrins National Park showed significant increases in the vegetation index, reflecting the greening process. The greatest increases were seen in rocky habitats at altitudes of over 2,500 m (Carlson et al., 2017), but they also depended on topography and orientation (Choler et al., 2021). Some animal species are also threatened by changes to their habitats. Finally, the presence of large predators, in particular the wolf, since the 1990s is changing the way pastoralists relate to the land.

Climate change is contributing to an **increase in natural hazards**. Mountain areas are subject to specific risks such as landslides, either slow or in the form of torrential flows (Bellec et al. 2015), for which several municipalities within the Lautaret-Oisans platform are considered highly exposed in the 2022–2027 flood risk management plan to which the region belongs (PGRI, 2022). Glacial and periglacial hazards, with the glacial lake outburst flood, as was the case at Arsine in 1986, are likely to increase. Finally, in the hot season, the increase in droughts and heatwaves leads to an increase in the risk of forest fires, as was the case in the summers of 2022 and 2023 in the Grenoble region.The effects of climate change are highly dependent on altitude and the environments considered in each mountain range.

Socioeconomic drivers: The required responses need to be tailored in line with demographic trends in the French Alps; the population of Lautaret-Oisans is declining. The Oisans region, for example, loses an average of 0.5% of its inhabitants each year (INSEE, 2014). Within mountain resorts, the population varies widely according to the seasons: while less than 1,500 people live in Huez all year round (Chambre régionale des comptes, 2021), up to 26,000 people are present in the municipality at peak times.

The area is also marked by the decline in pastoral activities and vegetation development due to the rural exodus following the Second World War and the intensification of farming on lowland meadows. However, livestock farming has been maintained in certain areas (Hinojosa et al., 2018), and mountain farmers often depend on the diversification of their economic activities, often in the tourism sector. As a result of agricultural policies and markets, pastoralism has largely shifted from dairy cows to sheep, apart from Savoie, where Beaufort cheese has a European Protected Designation of Origin. At the same time, public policies have had a limited impact on the development of agri-environmental practices, as they are not very restrictive compared to the practices in place (interviews; Bruley et al., 2021).

Tourism has a strong influence on regional planning. The stagnation or decline in skiing activities, the loss of tourism market share in the Alpine countries, the increased competition between tourist destinations, and the effects of climate change all call into question the future of skiing in the mountains (Bourdeau, 2009) and the dependence of these areas on income from winter tourism. In response, the government encourages the **diversification of resort activities** and the development of "4-season" tourism. However, new challenges arise as the development of tourist activities outside the winter period creates **conflicts of use with pastoralism**: herds grazing in summer pastures and guard dogs come into contact with tourists.

At the same time**, investments are made in equipment modernization** (Fonds Avenir Montagnes) to continue snow-related activities with a commitment to more environmentally friendly practices. The interviews revealed that the main resorts in the Lautaret-Oisans region, thanks to their high altitude, have the capacity to continue winter sports activities, with developments guaranteed to be profitable over 30 years. However, the interviews also show that **strategic visions diverge** between the two administrative regions covered by the Lautaret-Oisans area.

Conflicts over the use of water resources are multiplying, with the resources having to be shared among domestic use, agricultural and pastoral use, tourism (artificial snowmaking), hydroelectric production, etc., and climate change is set to increase this pressure. In addition, water storage facilities such as hill reservoirs have been built, but these facilities are the subject of numerous local and national protests. Finally, **natural areas are subject to conservation and management policies**: objective documents for Natura 2000 sites, scientific strategy for the Écrins National Park, landscape plans, national monitoring, pastoral surveys, monitoring of wolf permanent presence zones, agri-environmental measures, etc.

18.3.2Pressure

Bajard et al. (2017) studied the evolution of pedogenetic processes and evolution based on sediments from the La Thuile lake (Savoie) and concluded that man appears to be a major agent of pedogenesis in mountain areas. **Land use planning to organize tourist, pastoral, and forestry activities, the use of natural areas, and pollutant discharges are the main pressures** exerted on the environment.

Human activities in mountain areas shape the landscape through their practices and land-use planning. In mountain areas, new tourist units (UTN) are an exception to the principle of urbanization in continuity with existing development, allowing tourism-related projects to be built in natural areas, which usually lead to soil degradation and artificialization. For example, a UTN at Valloire concerns the construction of a Club Med with a surface area of 41,000 m2. Furthermore, mountain activities (skiing, summer sledging, mountain biking, etc.) often require land leveling, which, of course, disturbs the soil.

Housing is also a problem due to the predominance of tourist accommodation and the phenomenon of "cold beds" or "closed shutters", which refers to accommodation occupied for a few days or weeks per year. For example, 65% of tourist beds in Huez are considered underoccupied. This chronic underoccupation of tourist accommodation increases land pressure and encourages urban sprawl and the artificialization of land.

The use of natural areas by tourism and pastoralism affects the environment. As far as tourism is concerned, certain areas are considered to be over-frequented by local stakeholders. This observation is confirmed by the Office Français de la Biodiversité (French Biodiversity Office), which predicts a 20–30% increase in the number of tourists visiting mountain areas between 2020 and 2022 (Assemblée Nationale, 2022). In winter, although there are some exceptions to this rule (ski touring, snowshoeing, etc.), winter sports resorts concentrate tourist flows. In summer, on the other hand, visitor numbers are more diffuse, potentially affecting more vulnerable areas. In addition, certain one-off events, such as sporting competitions, also help to concentrate tourists in restricted areas. Finally, high-altitude roads modify the natural slopes and plant cover. As far as pastoralism is concerned, links have been established between the presence of the wolf and the reduction in the areas used for alpine pastures: some wooded or hilly areas are avoided, and the animals are placed in pens at night to avoid predation. This concentration of livestock in restricted areas increases the pressure on the fauna, flora, and soil in these areas (interviews; Zhao et al., 2017).

18.3.3State

Changes in the socio-ecosystem have had an impact on land use in the Lautaret-Oisans (Quétier et al., 2007; Girel et al., 2010; Lavorel et al., 2017). Areas devoted to summer grazing and sloping pastures have accounted for around 50% of the land since the early 19th century, but arable and mown grassland have been reduced, respectively, in favor of mown terraces and grazed grassland.

Since the 1970s, in the Lautaret region, mown terraces have also tended to become grazed. These trends are leading to a **"simplification" of the landscape**. The researchers interviewed also mentioned the end of food crops and an increase in the area of grazed, unfertilized grassland. On the other hand, those involved in pastoralism fear the overgrowth of plots of land, particularly on the outskirts of villages.

Artificialization and soil erosion are mainly concentrated in the resorts. The rate of soil sealing in mountain resorts is higher on average (1.29%) than in mountain municipalities (1.05%). However, it remains close to the national average (1.26%) (Ministry for Ecological Transition, 2020). In addition, the design of ski runs often leaves the ground without vegetation cover. The paths used by hikers and new practices (mountain biking, trail running) are also particularly vulnerable to erosion.

Regarding **soil pollution**, the active molecules in **anti-parasite treatments for livestock**, such as ivermectin, can end up in the soil via excrement, impacting soil biodiversity (Alvinerie et al., 2004; Perrin, 2019). Some tourist behavior, such as littering, could have an impact on soils as well, but these impacts are not well studied or quantified. Finally, in interviews, the research community noted that **the salt** used for roads in winter contributes to the **salinization of nearby soils** on a one-off basis.

The soils of high-mountain ecosystems contain large quantities of carbon. The soils of grasslands in the European Alps can harbor between 53 and 260 Mg ha−1 of soil organic carbon (Khedim et al., 2022). A study carried out in Lautaret-Oisans, where alpine grassland plots were transplanted from the alpine to the subalpine site, showed a strong reaction of the soil to climatic disturbances. In this experiment, a 3°C increase in temperature led to a reduction in the stock of organic carbon in the topsoil (Khedim et al., 2022).

Finally, global warming is leading to the melting of glaciers and permafrost, affecting **soil stability**. In 2021, the Pilatte refuge (Ecrins) was closed due to the destabilization of the bedrock caused by the melting glacier. At the same time, **the expansion of vegetation partly explains the reduction in soil loss and the gradual improvement in soil characteristics** (Garcia-Ruiz and Renault, 2011).

18.3.4 Impacts

In Lautaret, landscape diversity is associated with multiple ecosystem services. Lavorel et al. (2019) conclude that the homogenization of landscapes in Lautaret since the 1970s has been accompanied by a reduction in cultural ecosystem services and an increase in regulatory ecosystem services.

However, these results cannot be transposed to the whole Lautaret-Oisans region, as some areas are subject to the expansion of natural vegetation. In terms of **production services, the** quality of soil influences the production of fodder, ranging from 1 to more than 9 tons of fodder per hectare depending on the grassland in the French high mountains (CGDD, 2018). This production contributes not only to the economy but also to human health via food, recreational activities in nature, psychological well-being, and social ties.

Regarding **regulation services,** tourism activities and infrastructure have a negative impact on vegetation and soils, reducing the capacity of ecosystems to control erosion and natural hazards. In addition, water resource developments such as hydroelectric dams and hill reservoirs are modifying or even breaking ecological continuity. The impact of this on soil biodiversity is not well known.

With regard to **heritage, cultural, and recreational services,** the homogenization of landscapes, some of which have a high heritage value, is considered a major issue by stakeholders. These areas help to attract tourists, and their deterioration has a negative economic impact on local communities. In addition, tourism and research stakeholders have highlighted that the mountains offer a place of climatic refuge during heatwaves for both people and wildlife.

18.3.5 Response

Numerous technical solutions for preserving soil, in particular adaptations based on ecosystems, were mentioned in interviews, at the workshop, and in the literature (Repe et al., 2020): Limiting land use by renovating existing buildings and building on sites already artificialized. Designing new tourist infrastructure and dedicated pathways to limit the impact on the soil. Restore degraded soils using local plant cover. For example, the Alpine National Botanical Conservatory is carrying out restoration work using local seeds in the Alps (CBNA, 2021).

Limiting the use of pesticides in gardens, along roads, etc. Interviews revealed that financial resources for road maintenance vary from one department to another, which has an impact on the implementation of strategies for taking soil into account in this maintenance.

Promoting "rewilding" (Faure, 2022). The question is raised about the Lauvitel wilderness reserve.

The importance of **elected representatives as drivers of change** was mentioned several times during the interviews. In Puy-Saint-André, the mayor has promoted the sparing use of undeveloped land by reducing the amount of land available for building and the creation of community housing (CIPRA, 2022). In this case, the municipality's reflections have been carried out with the residents.

Some of the solutions identified can be considered nature-based **solutions** that are proposed by research actors to deal with local issues, such as the abandonment of land or an increase in the vole population. However, it is worth noting that the stakeholders interviewed did not have the exact same definition of the concept. A **living lab for nature-based solutions is under construction** within the region with the Solu-biod research program, supported by the Zone Atelier Alpes. Although, at the time of writing this report, soil health challenges were not specifically targeted in this program, the thematic would be conducive to integrating specific objectives related to soil.

During the workshop, stakeholders shared their **concern about the over-solicitation of stakeholders** in an area where the number of stakeholders who can be mobilized remains limited, which could hinder the multiplication of co-creation initiatives.

18.4Conclusions

Based on this work, soil health doesn't seem to be perceived as a priority for the region by most of the local stakeholders. Environmental actions with a positive impact on soils seem to be rarely undertaken with soil preservation as their first objective. However, the research community, environmental associations, and the Alpine Convention are the driving forces behind the soil issue in Lautaret-Oisans and, more broadly, in the surrounding regions.

The **main needs identified** during this are:

- Developing a **common vocabulary** regarding soil health and nature-based solutions
- **Collecting data and developing knowledge about soil**. Topics raised in the interviews include mapping the level of soil degradation in the region, spatial variability of soil properties at the local level, soil carbon fluxes in the region, the phenomenon of greening, and the impact of different plant covers on soils.
- **Raising public awareness** about soil issues and supporting the implementation of the necessary measures to foster the adoption of new knowledge and practices by

stakeholders This involves developing **dissemination tools for different audiences;** the creation of a guide to soil protection for mountain farmers was mentioned.

- **Territorial planning and co-creation with** citizens were identified by the stakeholders engaged as relevant tools to foster sustainable soil management.
- **The opening of modes of governance to the resident**, as in the example of Puy-Saint-André, is seen as one of the levers for future adaptation. Several stakeholders involved in our work have expressed an interest in open innovation schemes, mentioning in particular the implementation of the Zero Net Artificialization objective as one of the potential areas for work.

Based on these observations, living labs could be a great way to foster the adoption of sustainable soil management practices in the region. We recommend building on existing initiatives such as the living lab under construction to avoid over-soliciting stakeholders who are already few in number and to promote synergies and efficiency in human and financial resources.

18.5 References

Agate Territoires. (2022). Observatoire du Changement Climatique dans les Alpes du Nord. Enneigement de la saison hivernale (Nov-avril) 2022. 2p.

Alvinerie M., Galtier P., Berny P., Fournier J.C., Kerboeuf D., et al. (2004). Evaluation de l'impact éco-toxicologique résultant de l'usage de médicaments antiparasitaires en élevage extensif. Colloque Pnetox, Mar 2004, Lyon, France. 1 p. hal-02825134.

Assemblée Nationale. (2022). Le tourisme de montagne et les enjeux du changement climatique, Rapport d'information n° 5127, fait au nom de la commission des affaires européennes.

Bajard M., Poulenard J., Sabatier P., Develle A-L., Giguet-Covex C., et al. (2017). Progressive and regressive soil evolution phases in the Anthropocene. *CATENA, 150*, 39 - 52. Doi : 10.1016/j.catena.2016.11.001.

Bellec P., Lavarde P., Lefebvre L. et Madignier ML. (2015). Propositions pour un cadre national de gestion durable des sols, cgaaer_14135_cgedd_010068-01_2015_rapport.pdf (agriculture.gouv.fr)

Beniston M., Diaz H.F. et Bradley R.S. (1997). Climatic change at high elevation sites: an overview. *Climatic Change, 36*, 233–251. https://doi.org/10.1023/A:1005380714349

Bourdeau P. (2009). From après-ski to après-tourism: the Alps in transition? Revue de géographie alpine 0–11. https://doi.org/10.4000/rga.1054

Bruley E. (2021). Les populations travaillent avec la nature pour co-produire l'adaptation aux changements globaux dans les Alpes françaises. Ecologie, Environnement. Université Grenoble Alpes. Français.

Carlson B. Z., Corona M., Dentant C., Bonet R., Thuiller W., Choler P. (2017). Observed long-term greening of alpine vegetation—a case study in the French Alps. *Environmental Research Letters*. 12. DOI : https://doi.org/10.1088/1748-9326/aa84bd

Chambre régionale des comptes Auvergne-Rhône-Alpes. (2021). Rapport d'observation définitive et sa réponse, commune d'Huez (département de l'Isère), exercices 2014 et suivants. 62p.

Choler P., Bayle A., Carlson B., Randin C., Filippa G., Cremonese E. (2021). The tempo of greening in the European Alps: Spatial variations on a common theme. *Global Change Biology. 27*. Doi : 10.1111/gcb.15820.

CIPRA. (2022). Save land, save soil - What do we need for a turnaround in land management in peri-urban areas?. 44p.

Crouzat E. (2015). Etude des compromis et synergies entre services écosystémiques et biodiversité : Une approche multidimensionnelle de leurs interactions dans le socioécosystème des Alpes Française. Sciences agricoles. Université Grenoble Alpes. Français.

CGDD. (2018). Évaluation française des écosystèmes et services écosystémiques – Milieux rocheux et de haute montagne. Rapport EFESE. 678p.

Faure E. (2022). Faune sauvage et paysages dans les Alpes françaises : convoquer le réensauvagement pour penser les dynamiques socio-écologiques. Biodiversité. Université Grenoble Alpes. Français.

French Ministry for ecological transition - Data and Statistical Study Service. (2020). Ski stations use nearly 300 000 hectares of land in the heart of natural spaces. *Datalab essentiel.*

Girel J., Quétier F., Bignon A., Aubert S. (2010). Histoire de l'agriculture en Oisans (Haute Romanche et pays faranchin, Villar d'Arène, Hautes-Alpes). Les cahiers illustrés du Lautaret, n°1.

Grosinger J. (2021) Multiple aspects of wealth creation in a social-ecological system of the French Alps. Geography. Université Grenoble Alpes. English.

GREC-SUD - Regional Climate Experts Group in Provence-Alpes-Côte d'Azur. (2018). Impacts du changement climatique et transition(s) dans les Alpes du Sud, Les cahiers du GREC-SUD édités par l'Association pour l'innovation et la recherche au service du climat (AIR). 48 p. ISBN : 9782956006060

Hinojosa L., Lambin E., Mzoughi N., Napoléone C. (2018). Constraints to farming in the Mediterranean Alps: Reconciling environmental and agricultural policies, Land Use Policy (75), 726-733, https://doi.org/10.1016/j.landusepol.2017.11.047.

INSEE. (2014). Hautes-Alpes : des arrivées toujours plus nombreuses - Insee Analyses Provence-Alpes-Côte d'Azur. 4p.

IPCC - Intergovernmental panel on climate change. (2019). Special Report on Ocean and Cryosphere in a Changing Climate.

Khedim, N., L. Cecillon, J. Poulenard, P. Barre, F. Baudin, S. Marta, A. Rabatel, C. Dentant, S. Cauvy-Fraunie, F. Anthelme, L. Gielly, R. Ambrosini, A. Franzetti, R. S. Azzoni, M. S. Caccianiga, C. Compostella, J. Clague, L. Tielidze, E. Messager, P. Choler, and G. F. Ficetola. (2020). Topsoil organic matter build-up in glacier forelands around the world. *Global Change Biology.* https://doi.org/10.1111/gcb.15496

Khedim N., Poulenard J., Cecillon L., Baudin F., Barre P., Saillard A., Billur B., Grigulis K., Lavorel S., Münkemüller T., Choler P. (2022). Soil organic matter changes under experimental pedoclimatic modifications in mountain grasslands of the French Alps, *Geoderma, 429*, https://doi.org/10.1016/j.geoderma.2022.116238.

Lavorel S, Grigulis K, Leitinger G, Kohler M, Schirpke U, et al. (2017). Historical trajectories in land use pattern and grassland ecosystem services in two European alpine landscapes. *Reg Environ Chang. 17.* 2251–2264. https://doi.org/10.1007/s10113-017-1207-4

Pepin, N. C., Arnone, E., Gobiet, A., Haslinger, K., Kotlarski, S., Notarnicola, C., et al. (2022). Climate changes and their elevational patterns in the mountains of the world. *Reviews of Geophysics*, 60, e2020RG000730. https://doi.org/10.1029/2020RG000730

Perrin W. (2019). Influence de la pression pastorale sur l'écologie des communautés de coléoptères coprophages et leurs rôles fonctionnels associés : implications pour la gestion des espaces naturels. Sciences agricoles. Université Paul Valéry - Montpellier III.

PGRI. (2022). Plan de gestion des risques d'inondation 2022-2027 pour le Bassin Rhône – Méditerranée. Stratégie nationale de gestion des risques d'inondation. Volume 1. 106p.

Quétier F, Thébault A, Lavorel S. (2007). Plant traits in a state and transition framework as markers of ecosystem response to land-use change. *Ecol Monogr. 77*. 33–52. https://doi.org/10.1890/06-0054

Repe A., Poljanec A., Vrščaj B. (2020). Soil management practices in the Alps. Link4Soils project report. 150p.

Rounce, R. *et al. (2023).* Global glacier change in the 21st century: Every increase in temperature matters.*Science***379**,78-83(2023).DOI:10.1126/science.abo1324

Contact information (Email): flavien.poincot@acta.asso.fr

19 Peatlands: Eastern and Midland, Ireland

Niall Curley & Branwen Miles, Copacogeca (Niall.Curley@copa-cogeca.eu, Branwen.Miles@copa-cogeca.eu), Sabine Jordan, Swedish University of Agricultural Sciences (sabine.jordan@slu.se)

19.1Regional Information

Ireland has a long-standing relationship with peat and peatlands, which have played a significant role in the country's history, economy, and landscape. Ireland is known for its extensive peatlands, covering approximately 20 % of the country's land area. Ireland has the 3rd highest proportion of land area comprised of peat in Europe, after Finland and Estonia. Peat has historically been an energy source in Ireland; peat was cut from bogs and used as fuel for energy (Table 19-1). Peat cutting became a significant industry, particularly in rural areas, providing employment and sustaining local economies. In recent years, Ireland has transitioned away from the use of peat as an energy source and there has been a growing recognition of the environmental value of peatlands with certain areas of significance designated as Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) and banned from industrial peat extraction in 2011. In 2020, Bord na Móna (semi-state company) cessed harvesting peat. The Climate Action Plan set targets and measures in relation to reducing agricultural production on peat soils under grassland and rehabilitation of peatland. Farmers and landowners that hold turbary rights can cut turf as normal their own use but as of 1st September 2022 it is illegal to sell or gift it to others.

Upon restoration of peatland soils, and depending on the site, brownfield bare peat sites, if left without rehabilitation or restoration will “scrub up” that means covered in fast growing birch woodland, especially if fertiliser is applied, as is the case with industrial sites. However, if they get targeted treatment such as cell bunding, drain blocking, hydrological management, Sphagnum inoculation then the soil will soon have a raised water table and possibly standing water on the surface for some of the year.

Table 19-1:Regional Infromation Eastern and Midland, Ireland

Dominant land use:	Agriculture, forestry
Secondary land use:	Previously energy peat production
Climatic Zone:	Temperate
Soil WRB classification:	Histosols
Soil type:	Peat

Dominant topsoil texture:	Peat; often highly decomposed
Soil threat(s):	Drainage of peatlands led to peat shrinkage, compaction, subsidence, erosion and greenhouse gas emissions
Stakeholders:	Farmers, forest owners, farm advisors, rural dwellers living in now depopulating and depopulated areas that once depended heavily on energy peat production.
Policy Strategy:	Some policies in Ireland that influence peatland use especially under agricultural use include the Water Framework Directive, Food Vision 2030, the Common Agricultural Policy, the National Biodiversity Action Plan and Climate Action Plan. The Department of Agriculture, Food and the Marine in Ireland has recently introduced the new Agri-Climate Rural Environment Scheme (ACRES) to provide financial support to farmers who adopt environmentally friendly practices.
Representative regions:	Midlands North West Region

19.2Stakeholder Interaction

The Figure 19-1shows the different categories of stakeholders interacted during the soil needs assessment workshops and interviews in the Eastern and Middland, Ireland. The workshop took place at a central location in the region on 28 June 2023.

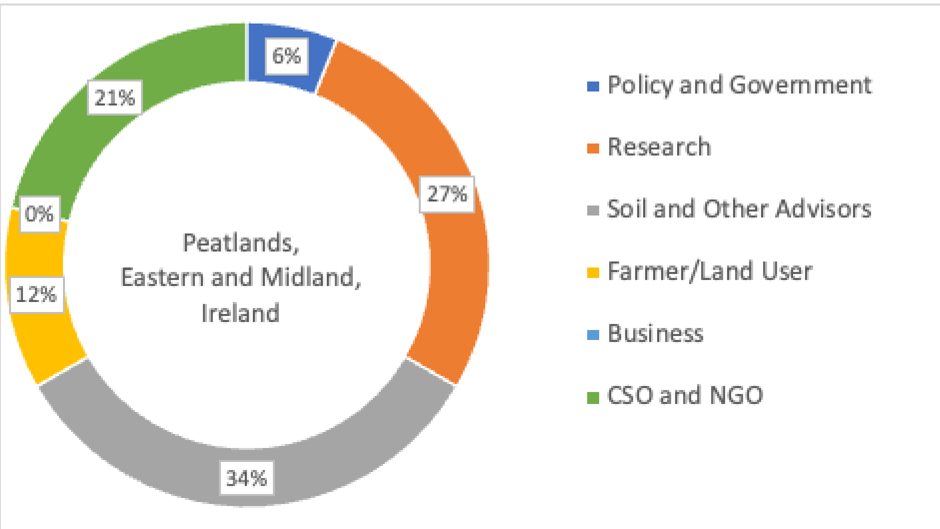


Figure 19-1:Stakeholder interaction in Eastern and Middland, Ireland

19.3Soil Needs Assessment

19.3.1Drivers

Biophysical drivers: Besides increased temperatures, climate change has other effects on the environment such as hydrologic conditions and the types of plants growing on the peat soil. These changing conditions could also impact the carbon sequestrating capacity of the peat soil. As drained peatlands produce high greenhouse gas emissions, they are more susceptible to wildfires. In that context, restoring and rewetting peatlands can help mitigate their greenhouse gas emissions and carbon losses, as well as reducing the risk of wildfires. This is important as droughts increase the risk for wildfires, while more frequent fires can switch peatlands from net carbon sinks to net emitters of greenhouse gases.

Peat extraction is not a recent development in Ireland: peat has probably been used as fuel for millennia, and this practice is still present to this day (Chapman et al., 2003). Traditionally, the peat is cut by hand, which was common by the 17th century (Department of Culture, Heritage and the Gaeltach, 2015). This practice can be sustainably managed, for example by replacing the uppermost horizon after extraction (Renou-Wilson et al., 2011). Peat extraction became industrialized in Europe in the 18th century, with the invention of peat-working machines. Extraction with machinery is much more invasive than the traditional practice: at a commercial scale, it can eradicate peatlands along with the services it provides. As a result, the ground water levels and microclimates are altered and can thus also affect habitats on adjacent lands, possibly at a regional level (Renou-Wilson et al., 2011). On top of that, peatlands are also subject to industrial harvesting and burning of peat from raised bogs to produce energy, and conversion of blanket and raised bogs to agriculture or commercial forestry by draining. At the same time, raised bogs have been damaged by machine harvesting, while many blanket bogs have been damaged by over-grazing (Bullock et al., 2012). Although the global area of peat extraction is not very extended, industrial extraction at a commercial scale has led to severe biodiversity destruction on both the peatland and its surroundings (Renou-Wilson et al., 2011).

Due to centuries of exploitation, forests made up only 1 % of the land by the end of the 19th century (Renou-Wilson & Byrne, 2015). As a response, restoration efforts were initiated in an attempt to recover this lost resource, but only sporadic afforestation efforts were attempted, which resulted in failure (Farell & Renou-Wilson, 2008).

In the late 1940's, the Irish government adopted a policy of large-scale afforestation over the country. It planned to increase the current afforestation rate of 4,000 hectares a year to a target of 400,000 hectares a year. In this era, peatlands were seen as "wet deserts", or "wastelands" as they were unproductive. It was also believed that trees, and conifers especially, were suited to grow on land unfit for agriculture. For these reasons peatlands were seen as an attractive location for afforestation, although wetland forestry was not common before as it was mainly used for peat extraction (Farell & Renou-Wilson, 2008).

However, there are reasons for Irish peatlands to have always been tree-less. They are not suited to support trees, as they are very acidic and have a low nutrient availability, especially regarding nitrogen and phosphorous (Renou-Wilson & Byrne, 2015). Solutions were found to address these issues: the application of phosphatic fertilizers and drainage (Farrel & Renou-Wilson, 2008). These solutions come with environmental trade-offs, such as peat soil degradation. Following the era's mindset, coniferous tree species from North America and North-Eastern Europe such as Sitka Spruce, Lodgepole pine, Norway spruce and Scots pine, were used for afforestation. Blanket bogs are subject to the most afforestation, although raised bogs were also afforested to a lesser extended (Renou-Wilson & Byrne, 2015).

Socioeconomic drivers: Overgrazing, agricultural drainage, commercial forestry plantation and domestic and commercial turf cutting affect Irish blanket bogs and associated peatlands. Those land use activities result in biodiversity loss, soil erosion, decline in water quality, reduction in carbon sequestration and increased rate of carbon emissions.

The horticultural sector represents a significant part of the Irish gross agricultural outputs. In 2018, the Irish horticultural sector had a farm gate value of 437 million euros. Of this sum, approximately half of these outputs are dependent on peat as a growing medium (Minister for Culture, Heritage and the Gaeltacht, 2019). The properties of peat make it a suitable growing media in horticulture, and is especially used to grow mushrooms, vegetables, and soft fruits (Minister for Culture, Heritage and the Gaeltacht, 2019).

The economics of the forestry programme have not been analysed before the late 1970's, and it was then seen as a social programme to provide employment. Gradually, the concept of forestry as a business began to take hold. Grants, until then reserved for small scale development, were then increased by schemes supported by the European Union. However, using blanket bogs for forestry gradually lost in attractivity, due to drainage difficulties, nutritional problems and the changing view of peatlands as a natural resource. Despite higher yields than expected, large scale afforestation was then no longer considered acceptable, due to a lack of economical profitability and environmental sustainability. On the other hand, while state afforestation declined, afforestation by private owners increased: the area subject to grant-aided private afforestation went from 500 hectares to 10,000 in 1990 (Farell & Renou-Wilson, 2008).

While afforestation does not seem like the most suitable land use on healthy peatlands, it could be the opposite for drained and damaged peatlands. The state-funded research programme BOGFOR was initiated in 1998 to investigate on and develop methods for successful afforestation on drained peatlands. Afforestation on drained peatlands was already being investigated in Finland, but as the finish bogs are much shallower, adjustments had to be made before being able to introduce this method in Ireland. The programme obtained successful results, when the three following conditions were met: a sound plan with specific objectives, a selection of suitable sites and the use of specific operational methods tailored for the sites characteristics and species requirement. Several commercial forest crops have been found suited for certain sites, including various conifer species and broadleaved species. The Norway spruce in particular has been found to be the most suited species. While information is lacking for the long term performance of various species, the range of species suited for afforestation of drained peatlands is wide enough to allow foresters to create multispecies, and therefore more sustainable forests. It should however be noted that the heterogeneity in conditions of peatlands can compromise successful afforestation in certain drained sites. Afforested drained peatlands could play a role in national wood production, and the objectives of the National Peatlands Strategy will provide direction for the future of Irish peatlands. In that context, it is likely that restored and drier habitats, where birch and willow have naturally recolonized, will be favoured over large-scale commercial plantations (Renou-Wilson et Byrne, 2015).

Peatlands in their natural state are not best suited for agricultural purposes, as the important amount of water can negatively impact crop productivity. Draining peatlands can thus offer the opportunity to increase yields. Draining land also resulted in an increase of its market price value. Two types of drainage exist to this end: arterial drainage consists of widening and deepening the main rivers; while field drainage comprises the activities done at the field level to remove surplus water from fields. These practices were often used complementarily to maximize their efficiency. As early as the eighteenth century, the Irish government promoted these practices, through programmes which provided funds (for example through the Arterial Drainage Act of 1945). While this programmes were mostly addressed to arterial drainage, field drainage was also funded through similar schemes (Bruton and Convery, 1982). However, peat loss occurs when the peatland is drained, as a result of increased aerobic decomposition. Peat loss then leads to carbon dioxide and nitrous oxide emissions. Although draining does lead to decreased methane emissions, and thus a short-term cooling effect, it results in a climate-warming effect in the long run, as carbon dioxide and nitrous oxide are more persistent than methane (Ojanen and Minkkinen, 2020).

19.3.2Pressures

Peatlands are an inherent feature of the Irish landscape and are part of the Irish culture and habits (Department of Culture, Heritage, and the Gaeltacht, 2015). The counties of Donegal, Sligo, Mayo, Galway and Kerry, as well as the Slieve Blooms, have the highest proportion household which use peat as their main source of fuel (O'Keeffe and Crowley, 2019a). In these areas, bogs are usually family owned, on small parcels, where turf cutting occurs on a small scale. The Irish uplands cite the opportunity for turf production, along with sheep rearing and forestry planting, as a strength of farming in the uplands (IUF, 2009). As the range of economic activities on peatlands is narrow, limiting these activities could have a negative impact on the livelihood of the rural populations.

For the reasons of climate mitigation, the Irish Government has switched from funding peatland drainage to peatland restoration programmes. For example, the National Peatlands Strategy of 2015 has set out a new vision for the management of peatlands in Ireland, with a greater focus on conservation and restoration (Department of Culture, Heritage and the Gaeltacht, 2015).

Rewetting the peatland after it has been drained can reverse this warming effect. By decreasing nitrous oxide and carbon dioxide emissions, the rewetted peatland has a long-term cooling effect on the atmosphere (Ojanen and Minkkinen, 2020). However, restoration can be compromised by residues of fertilizers left from agricultural activities, as the level of certain nutrients can have an effect on the species composition of the peatland (Andersen et al., 2016). Farmers spent their lives extracting peat and now they rewet. This should be seen as a benefit for the community. Regarding the communication around rewetting and restoration, many farmers fear what it means for their farm and highlight the importance of getting the correct information from the right people. There is many miscommunication, which is creating fear.

19.3.3State

The damaging effects of peat extraction in peatlands were realized by the Irish Government. This led to identification of the most important peatlands for protection and their categorization under the Special Areas of Conservation (SAC) under the Habitats Directive and Natural Heritage Areas under the Wildlife Acts. Fifty-three raised bogs were selected in that regard, due to the significant area of active raised bog, where the conditions are suited for peat formation, allowing both animal and plant communities to thrive. A significant amount of these bogs was found in the east midlands and were owned to a large extent by Bord na Móna or the Land Commission. The ownership of these lands was transferred to the state for conservation, with the agreement of both parties (Department of Culture, Heritage and the Gaeltacht, 2015). Bord na Móna announced the ending of all peat harvesting on its land by 2021, leading to the end of industrial peat extraction for energy purposes. The only peat production was turf cutting to produce sod peat, almost exclusively for domestic residential consumption (SEAI, 2022).

Currently, peat is mainly used as a growing media for the horticultural industry, and to a decreasing extent for domestic energy production (Murphy et al., 2015). The share of peat in

Irish electricity production peaked in the 1960's, reaching 40 % (Science, 2018). The use of peat has been declining since 2019, due to its price and high carbon dioxide emission per unit of energy, while domestic use is still ongoing and making up a significant part of the energy production in Ireland. In 2021, energy produced from peat accounted for 4.2 % of Ireland's indigenous production (SEAI, 2022). There, rural employment is the most important motive to keep peat as an energy source (Renou-Wilson et al., 2011). It should be noted that the interest in peat as a source of energy can fluctuate and re-emerge following a crisis. Such a thing occurred in Ireland after the Second World War, as the coal supplies from Great Britain almost ceased (Renou-Wilson et al., 2011). In 2014, the consumption of peat for energy generation represented 4.1 % of all greenhouse emissions of Ireland, making peat combustion a significant contributor to Ireland's greenhouse gas emissions (Devlin & Talbot, 2014). Household peat burning caused 840,000 tonnes of CO_2 emission in 2018 (O'Connell et al., 2021).

The horticultural sector is still heavily dependent on peat, particularly mushrooms and non-indigenous vegetation, such as bell peppers, tomatoes etc. Decreased availability of peat could therefore have an important impact on this sector, which is now looking for alternatives for growing media (Minister for Culture, Heritage, and the Gaeltacht, 2019; IRL, 2022). Since 2019, industrial peat extraction has been banned in Ireland. As the sector has not been able to find efficient peat-free alternatives, it has been relying on peat imports from the Baltic countries, such as Latvia (Irish Times, 2021).

19.3.4Impacts

In the 20th century, Bord na Móna was established by the Irish government in the aim of large-scale peat production, mainly in the midlands. This company previously produced peat for energy in Ireland (Murphy et al, 2015), but also for agricultural and horticultural purposes. These activities have significantly supported employment and indigenous energy provision, but have also resulted in significant damages on the Irish peatlands (Department of Culture, Heritage and the Gaeltach, 2015). For the majority of the history of the Irish state, the Irish government has supported peat extraction on a commercial and private level. As late as in the 1980's, the Government introduced a private bog scheme which subsidized the redevelopment of private bogs and the purchase of machinery (Department of Culture, Heritage and the Gaeltacht, 2015).

In the last 50 years, there have been changes in land-use patterns in Ireland including changes in agricultural practices, urbanisation, infrastructure development, and increased rates of afforestation. Large areas of peatland were transformed for grassland agriculture. Grassland systems continue to dominate as the primary land use systems in Ireland. Until recently it was assumed that all 335,000 ha of mapped grassland peat soils were drained. But latest research shows that the proportion of grassland peat soils actually drained is much lower than the current estimate (90,000 to 120,000 ha). Under Ireland's Climate Action Plan 2023, there are measures to (i) reduce the management intensity of grasslands on 25,000 ha of drained organic soils and (ii) rehabilitate 33,000 ha of peatlands as part of the Bord na Móna 2 Enhanced Decommissioning, Rehabilitation and Restoration Scheme and LIFE People and Peatlands programmes by 2030.

A lot of income in this region comes from intensive farming. Peatland rewetting would reduce farming intensity but also income in the beginning before new economic valuable land uses on wet peatlands have been installed. There are many farmers whose rewetting will impact neighbouring farms who are not involved in rewetting programs. They need to be informed. A number of current European Innovation Projects (EIP), Farm Carbon and FarmPEAT, are looking at intervention to support farmers to more sustainably manage of peatlands. Bord na Móna launched the Peatlands Climate Action Scheme which aims to rehabilitate approx. 33,000 hectares in over 80 Bord na Móna bogs.

19.3.5Response

Today, forests make up 11.6 % of the Irish landscape (Department of Food, Agriculture and the Marine, 2022). Despite remaining the country with the lowest forest cover in the EU, this is the highest it has been for the last 350 years. Half of these forests belong to the state, and are managed by the semi-state company Coillte, while the remaining is shared between 23,500 private land owners, mainly farmers. The Irish government wishes to continue the expansion of forests over its territory, while mentioning in its plan for 2022-2030 that the impact of forests on peat will be assessed and management decision will be implemented based on scientific information (Department of Food, Agriculture and the Marine, 2022).

Currently, peat extraction is limited to domestic use, after the ban on commercial peat harvesting by the High Court in 2019 (The Journal, 2022). After decades of activity, Bord na Móna has ceased all peat extraction activities, with the last peat harvest conducted in 2019. The company has turned towards more environmentally sustainable activities, such as renewable energy generation, recycling and developing other low carbon enterprise. According to Bord na Móna, this change in activities will contribute to Ireland's goal to be climate neutral by 2050, through their Brown to Green strategy (Bord Na Móna, 2021). These events hint that the declining trend of the use of peat for energy probably will not be reversed in a close future.

The two programmes below aim at restoring and protecting the Irish peatlands. The **Farm Peat Programme** is addressed at farmers managing the land surrounding raised bogs in Ireland. Eligible areas include areas located in the surroundings of the following eight raised bogs: Ballynamona Bog and Corkip Lough, the Clara bog, the Clonboley Bog, the Cloncrow bog, the Daingean bog, the Ferbane bog, the Raheenmmore bog and the Umeras bog. The project team assesses and scores the farmland habitats and will then identify a plan and actions to improve this score. These actions are voluntary, up to the will of the farmer. A payment will be provided to the farmer, to help funding supporting actions taken to improve the score of the farm (FarmPEAT, 2023). This project was funded for 2 years until 2023, with a total budget of 1.2 million euros (FarmPEAT, 2023).

The **Wild Atlantic Nature LIFE Integrated Project** aims at increasing conservation efforts to improve the conservation status of blanket bogs in the Special Areas of Conservation (SAC) Network. The main area of focus is on 35 Natura 2000 sites the northwest of Ireland. The projects work with farmers and local communities to restore the blanket bogs and its associated habitats, as well as the ecosystem services they provide. This project was provided funding for 9 years (2021-2029), and is led by the Department of Housing, Local Government and Heritage (Wild Atlantic Nature, 2023).

To achieve its goals, this project introduces a pilot voluntary Result Based agri-environment Payment Scheme (RBPS) linked with the quality of the habitat. This way, the skill, expertise and knowledge of the landowner is at a central position of the project. The project will also implement actions aimed at widening and increasing community engagement. This will be done through establishing local support group, developing and implementing community knowledge exchange programme, administering community outreach activities, developing a school education programme, supporting communities to develop and manage tourism and recreational activities and develop appropriate infrastructure. A national campaign aimed at increasing public awareness and appreciation of the Natura 2000 network in Ireland will also be part of the programme. Other actions are also planned, such as site surveys, ecological assessment, training for concrete conservation actions, control of invasive species, fire prevention, water management and monitoring and evaluation (Wild Atlantic Nature, 2023).

On the workshop it was highlighted, that the current CAP programme has nothing prescriptive on peat. An advisor shared his experience with farmers regarding the communication around rewetting and restoration. Many were fearing what it meant for their farm and highlighted the importance of farmers getting the correct information from the right people. Many of the changes are going to be a service to the community. This comes with its own challenges including communicating it to the wider community and even for farmers moving away from a productive view (public good). It was mentioned that whilst you can consistently have measures for restoration, where is the money going to come from to keep them going? None of the eco schemes look at peatlands. If you look at short/medium/long term goals, there needs to be short/medium/long term payment/funding. Example was given of forestry which provides a long-term payment, and if it can be done maybe this is what should be aimed for

19.4 Conclusions

It has been established that Irish peatlands are valuable, and the damage done by anthropogenic activities should therefore be repaired. To conserve and improve peatlands is to work with farmers and local communities by developing measures, such as base line site surveys, ecological assessments, training for conservation actions, fire prevention and water management. The role of climate officers and effective communication with farmers must be emphasized, along with the need for realistic and less bureaucratic approaches.

19.5 References

Andersen, R., Farrell, C., Graf, M., Muller, F., Calvar, E., Frankard, P., Caporn, S., Anderson, P. (2016). *An overview of the progress and challenges of peatland restoration in Western Europe*. Restoration Ecology, 25, 2, 271-282

Bord na Móna (2021). *Bord na Móna announce formal end to all peat harvesting on its lands*. https://www.bordnamona.ie/bord-na-mona-announce-formal-end-to-all-peat-harvesting-on-its-lands/ (Retrieved on 24.03.2023)

Bruton, R., Convery, F. J. (1982). Land drainage policy in Ireland. The Economic and Social Research Institute, Dublin. http://aei.pitt.edu/98971/1/PRS4.pdf (Retrieved on 27.03.2023).

Bullock, C. H., Collier, M. J., Convery, F. (2012). *Peatlands, their economic value and priorities for their future management – The example of Ireland*, Land Use Policy. 29, 4, 921-928. https://doi.org/10.1016/j.landusepol.2012.01.010.

Chapman, S., Buttler, A., Francez, A. J., Laggoun-Défarge, F., Vasander, H., Schloter, M., Combe, J., Grosvernier, P., Harms, H., Epron, D., Gilbert, D., Mitchell, E. (2003). *Exploitation of northern peatlands and biodiversity maintenance: a conflict between economy and ecology*. Frontiers in Ecology and the Environment. 1, 10, 525-532. https://doi.org/10.1890/1540-9295(2003)001[0525:EONPAB]2.0.CO;2

Department of Culture, Heritage and the Gaeltacht. (2015). *National Peatlands Strategy*. Dublin, Ireland: Stationery Office. https://www.npws.ie/sites/default/files/general/Final%20National%20Peatlands%20Strategy.pdf

Department of Food, Agriculture and the Marine. (2022). *Ireland's Forest Strategy (2022 – 2030) Draft for public consultation.* https://assets.gov.ie/237557/a425b8a9-0dc5-458b-9aa9-682456f89fdb.pdf

Devlin, G., Talbot, B. (2014). *Deriving cooperative biomass resource transport supply strategies in meeting co-firing energy regulations: A case for peat and wood fibre in Ireland*. Applied Energy, 113, 1700-1709. http://dx.doi.org/10.1016/j.apenergy.2013.09.019

FarmPEAT (2023). *FarmPEAT Programme.* https://www.farmpeat.ie/programme

Farrell, E. P., Renou-Wilson, F. (2008). *A new paradigm for Irish peatland afforestation.* After Wise Use – The Future of Peatlands, Proceedings of the 13th International Peat Congress: Peatland Forestry. https://peatlands.org/document/a-new-paradigm-for-irish-peatland-afforestation/

Irish Times (2021). *Peat imports into Ireland 'make no environmental, economic or ethical sense*. https://www.irishtimes.com/news/environment/peat-imports-into-ireland-make-no-environmental-economic-or-ethical-sense-1.4728349 (Retrieved on 24.03.2021)

IRL (Irish Rural Link). (2022). *Final Report on the assessment of the Levels and Suitability of Current Indigenous Peat Stocks and Identification of Sub-Thirty Hectare Sites and other recommendations to support domestic horticulture industry as it transitions to peat alternatives*. https://assets.gov.ie/239224/d37dc3bd-2e2c-40a3-a0de-f0b3d413c2b4.pdf

IUF (Irish Uplands Forum) (2009). *Challenges, Changes and Opportunities in the Irish Uplands Research Report*. http://irishuplandsforum.org/wp-content/uploads/2022/02/IUF-Challenges-...-report-pdf.pdf

Murphy, F., Devlin, G., McDonnell, K. (2015). *Benchmarking Environmental Impacts of Peat Use for Electricity Generation in Ireland—A Life Cycle Assessment*. Sustainability, 152, 830-837. *doi:10.3390/su7066376*

Minister for Culture, Heritage and the Gaeltacht (2019*). Review of the use of Peat in the Horticultural Industry - Submissions Received.* https://www.npws.ie/sites/default/files/general/peat-horticultural-industry-consultation-paper-en.pdf (Retrieved on 01.03.2023).

O'Connell, C. A., Madigan, N., Whyte, T. & Farrell, P. (2021) *Peatlands and Climate Change Action Plan 2030. Irish Peatland Conservation Council, Co. Kildare. http://irishuplandsforum.org/wp-content/uploads/2021/04/Peatlands-Climate-Action-Plan-2030-Compressed.pdf*

Ojanen, P., & Minkkinen, K. (2020). Rewetting offers rapid climate benefits for tropical and agricultural peatlands but not for forestry-drained peatlands. Global Biogeochemical Cycles,34,e2019GB006503. https://doi.org/10.1029/2019GB006503

O'Keeffe, B., Crowley, C. (2019). *A Profile of Ireland's Uplands. An all-island study hightlighting their strategic importance. Executive summary. Irish Uplands Forum* http://irishuplandsforum.org/wp-content/uploads/2020/06/Executive-Summary-A-Profile-of-Irelands-Uplands1.pdf (Retrieved on 22.03.2023)

Renou-Wilson, Florence & Bolger, Thomas & Bullock, Craig & Convery, Frank & Curry, J. & Ward, Shane & Wilson, David & Müller, C. (2011*). BOGLAND - Sustainable Management of Peatlands in Ireland.* https://www.researchgate.net/publication/233924489

Renou-Wilson, F., Byrne, K. A. *(*2015). *Ireland Peatland Forests: Lessons from the Past and Pathways to a Sustainable Future*, Restoration of Boreal and Temperate Forests, 2, 321-333 https://doi.org/10.1201/b18809

SEAI (Sustainable Energy Authority of Ireland). (2022). *Energy in Ireland, 2022 Report.* https://www.seai.ie/publications/Energy-in-Ireland-2022.pdf (Retrieved on 28.02.2023).

The Journal (2022). *Calls to allow commercial peat harvesting but expert says it would be a 'bad step' for climate* https://www.thejournal.ie/peat-harvesting-ban-ireland-5707118-Mar2022/#:~:text=Commercial%20peat%20harvesting%20in%20Ireland,consequent%20fuel%20%26%20energy%20challenge%E2%80%9D. (Retrieved on 24.03.2022)

Wild Atlantic Nature (2023). *Life IP Wild Atlantic Nature.* https://www.wildatlanticnature.ie/wild-atlantic-nature/

20 Reforestation: Vysočina, The Czech Republic

Karel Charvát (charvat@lesprojekt.cz), Jaroslav Šmejkal (smejkal@lesprojekt.cz)

20.1 Regional Information

The Vysočina "Highlands Region", (G) of the Czech Republic is located partly in the southeastern part of the historical region of Bohemia and partly in the southwest of the historical region of Moravia (https://www.kr-vysocina.cz/). Its capital is Jihlava. The region is the location of two mountain ranges, Žďárské vrchy and Jihlavské vrchy, and is home to three UNESCO World Heritage Sites, the most in any region in the Czech Republic (Figure 20-1 AND Table 20-1).

Figure 20-1:Map of the Self-governing region Vysočina, The Czech Republic

Source: https://www.mapy.cz/

As of January 1, 2019, the population of the Vysočina Region was 509,274, which was the third lowest in the Czech Republic. The density of Vysočina Region is the second lowest in the Czech Republic (75 inhabitants per km2). With mean annual temperatures of 5-7 degrees Celsius, Vysocina is one of the colder regions of the Czech Republic. Vysočina is a region with the highest percentage of SME employment and one with the lowest incomes, which is now also influenced by COVID-19 and the Ukraine crisis. The regional priority is overall digitalization, including agriculture, forestry, and tourism.

Table 20-1:Regional information of Self-governing Vysočina, The Czech Republic

Dominant land use:	Agriculture land 61 %.
Secondary land use:	Woodland 30%.
Climatic Zone:	Moderate Continental.
Soil WRB classification:	Dystric Cambisol, Gleyic Luvisol.
Soil type:	Medium
Dominant topsoil texture:	Medium
Soil threat(s):	Erosion, Acidification
Representative for regions:	Jihlava.

20.2Stakeholder Interaction

A regional stakeholder workshop was organised on 19th May 2023 with various stakeholder groups (Figure 20-2).The workshop was a combination of presentations, interactive engagement using Mentimeter technology, and dialogue with stakeholders. The workshop included a series of technical presentations, including one with PowerPoint slides explaining the utilization of sensors, conducted by Michal Kepka. The remaining presentations were live demonstrations showcasing various aspects, technologies, and data related to soil management.

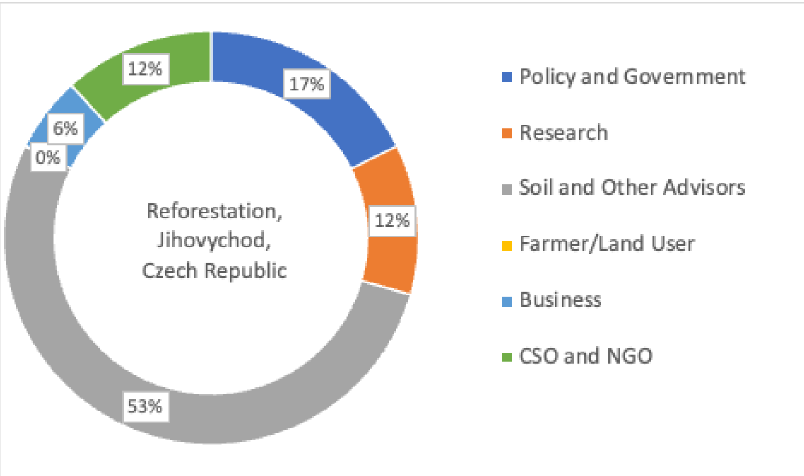


Figure 20-2:Stakeholder interaction in Vysočina, The Czech Republic

20.3Soil Needs Assessment

20.3.1Drivers

Agriculture biophysical drivers:

Climate Change: Climate change is identified as a significant biophysical driver affecting agriculture in Vysocina. It involves changes in temperature, floods, droughts, and wind storms. These changes can have adverse effects on agricultural production, impacting crop growth, water availability, and overall farm productivity.

Erosion: Vysocina being a highland region, water erosion is recognized as a serious problem. Erosion can lead to the loss of fertile topsoil, reduced water-holding capacity, and nutrient depletion in the soil. It can adversely affect crop growth and agricultural productivity. Implementing erosion control measures such as contour plowing, terracing, and cover cropping can help mitigate the impact of erosion. These measures are now discussed as part of Czech legislation. Some farms have already implemented some of these measures.

Crop diversification: Changes in crop composition, particularly in response to climate change and erosion, play a significant role in influencing soil health. In the last year, due to the production of biogas, there was an extremely increased production of corn, which is not optimal for highlands. Typical crops are cereals and potatoes. Crop selection and diversification can help manage soil erosion, maintain soil fertility, and improve resilience to pests and diseases, but till now, there is no clear strategy. Choosing suitable crop varieties that are adapted to changing climatic conditions and implementing sustainable agricultural practices (smaller fields, no-tillage, contour farming, biocoridors) can contribute to maintaining soil health in the long term.

CAP Subsidies: The influence of subsidies linked with the Common Agriculture Policy on crop composition in the Vysocina region is identified as one of the key drivers. Subsidies from CAP that promote commercial crops significantly influence the farmers' crop choices. Due to the nature of incentives, farmers are inclined to grow those crops (mainly corn), even if they are not well-suited to the local environment or have negative consequences for soil health. For example, subsidies may favor cash crops or monocultures that are profitable in the short term but may increase erosion and soil degradation over time. Moreover, monocultures may require more intensive use of synthetic fertilizers and pesticides, which can further impact soil quality and biodiversity. Monoculture leads to the depletion of specific nutrients (mainly nitrogen) from the soil, increased vulnerability to pests and diseases, and reduced soil structure. These factors can contribute to erosion and the degradation of soil health.

Considering these factors and their potential impacts, it is crucial to develop appropriate adaptation and mitigation strategies for agricultural practices. These may include implementing precision farming, climatic-focused farming using IoT soil conservation measures, adopting climate-smart farming techniques (smaller fields, contour farming,no tillage, biocoridors), promoting sustainable crop rotations, and enhancing water management practices to ensure the long-term productivity and sustainability of agriculture in the Vysocina region.

Forestry biophysical drivers:

Bark Beetle Calamity: The outbreak of bark beetles started in 2017, which was mainly influenced by large monocultures of spruce and partly influenced by climatic changes, mainly drought, and overall has been a significant driver impacting the current state of forestry in Vysocina. The calamity, resulting from the infestation of bark beetles, has led to widespread tree mortality and forest degradation. This driver has weakened the overall health and resilience of the forests in the region.

Climate Changes: The influence of climatic changes is another driver shaping the current situation in forestry. Shifts in temperature, precipitation patterns, and the occurrence of extreme weather events pose challenges to the existing tree species in the region. Some tree species may become more vulnerable to pests, diseases, or drought, while other species (name one or two) may struggle to adapt to the changing conditions.

Forest Monoculture: The current dominance of spruce monocultures is another driver influencing the state of forestry in Vysocina. The prevalence of a spruce tree species makes the forests more susceptible to pest outbreaks, as seen with the bark beetle calamity. Moreover, a lack of species diversity reduces the overall resilience and adaptability of the forest ecosystem.

In summary, the drivers influencing the current situation in forestry in Vysocina include the bark beetle calamity, climatic changes, and the dominance of spruce monocultures. Mainly, bigger diversity can make future forests more resilient. The vision for the future involves effectively managing the bark beetle infestation, adapting to climate change through species diversification, and promoting reforestation efforts that enhance forest composition. This vision aims to restore and build resilient forests that can thrive in the face of future challenges while ensuring the sustainability of soil health and ecosystem functions.

Socioeconomic drivers:

Agriculture's socioeconomic drivers:

Large Farms: The prevalence of large farms in Vysocina is a significant socio-economic driver. These farms are often much bigger than those found in other European countries. In Vysočina, the average farm area exceeded the national average and reached almost 93 ha. In 2005, out of a total of 584 cooperatives in the Czech Republic, 106 cooperatives operated in Vysočina, and, together with the South Bohemia region, this is the highest number of agricultural cooperatives in the interregional comparison. Cooperatives traditionally have the highest average. The area of cultivated land in Vysočina in 2005 was 1,419.4 ha. Significant disproportions in the area of agricultural land must be noted between the enterprises of legal entities and natural persons. For legal entities, the average area of cultivated land was 888 ha; for natural persons, the average was only 26 ha. The large farm size has implications for soil management, erosion, and biodiversity. It can be challenging to effectively manage and maintain the health of **large fields,** which can contribute to increased erosion and decreased biodiversity. The problems are that these farms are operating on fields bigger than 30 ha, and this influences the terrain relief, composition of production erosion, and biodiversity.

Land Tenure: Many farms in the region operate on land that is not owned by the farmers themselves but is instead leased or rented from non-farming landowners. It covers approximately 50 percent of land. This arrangement can lead to challenges, as farmers may not have a long-term interest in maintaining the health of the land.

Subsidies and Monoculture: Subsidies are suggested, such that they support the nonoptimal composition of crops in the highlands. Additionally, subsidies may contribute to the rising cost of land, making it difficult for new entrants to start farming and promoting the monopolization of food production. The number of new farmers is extremely low, but on the other hand, in more cases, children are taking farms from their parents.

Age and Education of Farmers: An aging farming population and a lack of young farmers entering the sector impact the adoption of sustainable practices and innovative approaches to farming. Furthermore, the low level of education and lack of access to knowledge and training among farmers results in poor ability to implement environmentally friendly and economically viable practices like contour farming, no tillage, etc.

Monopolization of Food Production and Retail: The concentration of power and control in the food production and retail sectors has implications for small-scale farmers, limiting their market access, bargaining power, and profitability. It may also contribute to a lack of diversity in the agricultural sector and hinder the development of sustainable farming practices. Mainly, retail is in hand with international global companies.

In addressing these socio-economic drivers, it is important to promote policies and initiatives that support sustainable land management, encourage the adoption of diversified farming systems, provide support for new entrants in agriculture, and foster knowledge-sharing and innovation. Creating a favorable environment for small-scale farmers and ensuring equitable access to resources and markets can contribute to a more sustainable and economically viable agricultural sector in Vysocina.

Forestry socioeconomic drivers:

Price of Wood: The bark beetle calamity, which has resulted in widespread tree mortality, has led to a decrease in the price of wood due to overproduction, which creates challenges for forest owners who rely on the sale of timber for their economic viability.

Cooperation between Forest Owners and the Wood Processing Industry: A lack of effective cooperation between forest owners and the wood processing industry is characterized by insufficient collaboration and communication, leading to difficulties in timber sales and value chain integration due to the low power of forest owners and the adaptation of forest management practices.

Small scale Owners: Vysocina has a high number of small forest owners; more than 92 percent of forest owners on Vysocina are physical persons, some of whom reside in other regions and may lack sufficient knowledge about forest production. This situation leads to limited capacity to implement management practices and results in suboptimal forest management. Limited knowledge and resources among small forest owners and administrative challenges in accessing subsidies hinder effective soil stewardship.

Complex Subsidy System: The complexity of the subsidy system poses challenges for small forest owners in Vysocina. The intricate requirements and administrative burdens associated with accessing subsidies can discourage their participation or hinder their ability to benefit from available support.

Forest Owner-Forest Manager Interaction: In some cases, there is limited interaction and collaboration between forest owners and forest managers. This disconnect can impede effective forest management planning, the implementation of sustainable practices, and adaptation to changing conditions.

Inadequate Forest Management Plans: Current forest management plans in Vysocina may not adequately address or reflect the challenges posed by climate change and other evolving factors, such as the integration of regional needs. These plans may require updating to incorporate measures that consider changing climatic conditions, promote forest resilience, and sustainably manage resources, taking into account factors such as the specific needs of the region, small-scale owners, and appropriate forest management practices and training.

20.3.2Pressures

The physical environment of Vysočina has witnessed notable shifts in recent years, mainly due to multifaceted pressures arising from biophysical and socioeconomic drivers.

Climate Change and Soil Management Practices: In Vysočina, the glaring effects of climate change have manifested as rising temperatures, altered precipitation patterns, and a heightened frequency of extreme weather events. These climatic shifts have had a pronounced effect on soil moisture, nutrient availability, and overall soil structure. Historically, the management of soil in the region revolved around traditional practices that did not necessarily account for such rapid environmental changes. However, these new pressures have compelled a shift in soil management tactics. The need to enhance water-holding capacity, nutrient retention, and soil resilience has never been more urgent. Moreover, to counteract these challenges, newer equipment and modernized operations, like enhanced irrigation techniques and soil moisture conservation strategies, have been incorporated in the last decade.

Erosion and Land Use: One of the stark changes observed in Vysočina's physical environment is the increased incidence of erosion. This, exacerbated by vast fields and inadequate land tenure systems, has led to the loss of fertile topsoil and a decline in water retention, thereby impacting crop growth and productivity. Previously, large-scale farming without significant erosion control measures was commonplace. Yet, in light of the recent challenges, methods such as contour plowing, terracing, and cover cropping have been integrated into agricultural practices. Furthermore, there's a growing emphasis on reducing field sizes and amending land tenure arrangements to promote a long-term commitment to soil health.

Socioeconomic Impacts and Soil Management Evolution: Crop composition, greatly influenced by subsidies, has seen a trend towards monocultures, leading to soil nutrient depletion and increased susceptibility to pests and diseases. Historically, subsidies often promoted these monocultures due to economic benefits. However, with the evident pressure on the soil, there's been a move towards promoting crop diversification and sustainable agricultural practices. Similarly, in the forestry sector, the dominance of spruce monocultures and fluctuating wood prices have impacted soil management decisions. The widespread bark beetle calamity has further altered forest management strategies.

While these shifts in soil management have been significant, they have not been abrupt. Equipment and operational changes have been progressive, often motivated by a combination of environmental necessity and economic feasibility. Farmers and landowners in Vysočina regularly update themselves on advancements in management practices.

Information is primarily sourced from local newspapers, agricultural seminars, and increasingly from internet platforms that offer insights into sustainable and effective soil management.

For Vysočina, the future envisions a landscape where the pressures of 2050 are preemptively addressed. The region aims to foster increased awareness, promote the adoption of sustainable soil management practices, and prioritize collaboration across sectors. The ultimate objective is to seamlessly integrate soil health considerations into everyday planning and decision-making processes, ensuring the long-term productivity and resilience of the soils in Vysočina.

20.3.3 State

Biophysical Situation: The state of Vysočina's soil has transformed over the years, reflecting the changes in the physical environment. As per current observations, several indicators suggest a shift in soil quality and health:

Soil Organic Matter: Historically, Vysočina's soil was enriched with organic matter. However, current practices, especially the prevalence of spruce monocultures and the impacts of the bark beetle calamity, have caused a decline in organic matter input. This reduction, in turn, affects the nutrient cycling processes of the soil.

Soil Erosion: The region's susceptibility to water erosion has been exacerbated by climate change. Increasingly inconsistent precipitation patterns lead to issues such as drought stress or waterlogging, affecting the overall fertility of the soil. Consequently, fertile topsoil loss is prevalent, reducing the nutrient content and water retention capacity of the soil.

Soil Nutrient Retention: The dominance of certain crops, often backed by subsidies, has impacted the soil's nutrient balance. Monocultures lead to nutrient imbalances and decreased soil biodiversity. Intensified use of synthetic fertilizers further compromises the soil's natural nutrient retention capability.

Soil Biodiversity: Both crop composition in agriculture and forestry practices have implications for soil biodiversity. Monocultures, both in crop fields and forests (like spruce), significantly reduce soil biodiversity, making it more vulnerable to degradation and less resilient.

Measurement and Monitoring Indicators: To assess the state of soil health effectively, it's imperative to rely on various indicators. Soil nutrient tests, microbial activity assessments, and organic matter content evaluations can provide comprehensive insights. Additionally, erosion mapping, using satellite imagery and ground surveys, can offer quantitative data on soil loss.

Overall Assessment of Soil's State: Comparing current observations with historical data, Vysočina's soil appears to be moving from a state of "healthy" towards "moderately healthy." This shift is primarily attributed to the combined effects of biophysical and socioeconomic pressures.

Socioeconomic Situation: Several socioeconomic factors, including farm sizes, subsidies, food production monopolization, and wood industry dynamics, are shaping soil management practices and, by extension, the state of the soil in Vysočina.

Large Farms and Land Tenure: The rise of large farms, many of which operate on leased lands, has led to a short-term vision for soil health. The transitory nature of tenure reduces the inclination for long-term soil conservation investments.

Subsidies and Monoculture: The subsidy systems in place often promote monocultures, leading to a range of soil health issues. These monocultures result in nutrient imbalances, reduced soil resilience, and biodiversity loss.

Monopolization of Food Production and Retail: The concentrated power within the food production and retail sectors has put immense pressure on small-scale farmers. This monopolization often drives them towards intensified farming, which includes the heavy use of inputs detrimental to soil health.

Forestry Economics: The plummeting wood prices, combined with the bark beetle calamity, have strained the economic sustainability of forestry. Consequently, there's limited incentive and resources for comprehensive soil management and restoration within the forests.

Biophysical Situation: The combined impacts of climate change, erosion, monoculture crop composition, and certain forestry practices have led to deteriorating soil health indicators in Vysočina, affecting nutrient balance, organic matter, and biodiversity.

Socioeconomic Situation: The existing socioeconomic landscape, dominated by large farms, skewed subsidies, and concentrated power in food production, is leading to suboptimal soil management practices. The result is reduced investments in soil health and a push towards unsustainable farming methods, further compromising the region's soil quality.

20.3.4Impacts

The intricate web of drivers, pressures, and states influencing Vysočina's soil health has generated a ripple effect on the broader ecosystem and the services it provides. Here's an assessment of the resulting impacts:

Ecosystem Services:

- **Provision of Materials (sand, clay, gravel, and rock):** The continuous erosion and degradation in soil quality may lead to reduced availability and quality of these materials, impacting construction and other related industries.
- **Soil-related Cultural Services:** The degraded soil quality can affect the visual appeal of the landscape, potentially undermining its cultural and archaeological significance.
- **Provision of Energy:** Soil degradation might affect the efficiency of geothermal energy sources and the potential exploration of fossil resources.
- **Provision of Food, Fiber, and Biomass:** Impaired soil health negatively affects crop growth and productivity, reducing the yield of food, fiber, and biomass.
- **Water Purification and Soil Contaminant Reduction:** Reduced soil health might hinder its natural ability to filter and purify water. The risk of nutrient leaching due to imbalances can contaminate water sources.
- **Water Flows Regulation:** Eroded soils with compromised structures may not efficiently regulate water flows, leading to increased flooding risks.
- **Drinking Water Resources:** Nutrient imbalances and potential leaching can risk contaminating drinking water sources.
- **Carbon Storage and Climate Regulation:** Decreased organic matter content can impact the soil's ability to store carbon, potentially aggravating climate change effects.
- **Support for Biodiversity and Nature:** The shift towards monocultures and the impacts of erosion have had detrimental effects on soil biodiversity, affecting the wider ecological balance.
- **Natural Attenuation to Soil Contamination:** Degraded soils might be less efficient in naturally attenuating contaminants, increasing risks to health and the environment.
- **Climate Change Mitigation: Soil Organic Carbon Sequestration and Greenhouse Gas Emission Reduction:** The depletion of organic matter content and reduced soil health may limit the soil's capability to sequester carbon, thereby not optimally mitigating greenhouse gas emissions.
- **Resource Use Efficiency Water, land, energy, phosphorus, and labor:** Reduced soil health means these resources are not utilized efficiently, leading to waste and increased costs.

- **Human Health:** Degraded soils can influence food quality, potentially introducing pollutants and affecting water quality. This has direct and indirect implications for human health, both physically and mentally.
- **Economic/Social/Rural Development:** The reduced soil health and fertility might hinder economic growth, especially in sectors relying heavily on the land, affecting both urban and rural development.
- **Land Use Resilience, Including Climate Change Adaptation:** The current state of soil in Vysočina, under the impacts of various drivers and pressures, questions the adaptability and robustness of the land, challenging its readiness for the future.
- **Land Use Performance:** In terms of agricultural systems, declining soil health impacts income and revenue on farms. The adaptability and transformability of these systems to address and rebound from these challenges will be vital for the region's sustainability.

20.3.5 Response

Future Vision for Vysočina in 20 Years: Envisioning a sustainable Vysočina, stakeholders aim to cultivate a landscape characterized by thriving agriculture, sustainable forestry, and balanced ecosystems. By 2043, the region should be a beacon of innovation where traditional values merge with contemporary sustainable practices. Farmers and forest owners would employ cutting-edge techniques that bolster soil health while ensuring productivity. Policymakers would enact adaptable regulations that prioritize the environment and the local economy. Moreover, a collaborative spirit would be the region's hallmark, with knowledge sharing and cooperative efforts at the core of all activities.

Requirements to Realize This Vision:

- **Education and Training:** Equip farmers, forest owners, and other stakeholders with the latest knowledge and techniques related to soil health and sustainable land use.
- **Infrastructure Development:** Ensure accessibility to modern equipment and technologies that enhance land management without compromising soil health.
- **Policy Reforms:** Policies should evolve to actively support sustainable practices, offering incentives for best practices and penalizing unsustainable actions.
- **Enhanced Collaboration:** Strengthen the collaboration between research institutions, policymakers, farmers, and forestry officials for cohesive action.

Barriers to Achieving the Vision:

- **Economic:** Complex subsidy systems that do not always align with sustainable practices could deter farmers and forest owners from transitioning.
- **Social:** There might be resistance to change, especially from stakeholders accustomed to traditional practices.
- **Technical:** The initial investment required for modern equipment and sustainable technologies might be prohibitive for some.
- **Legal:** Existing regulations might not be flexible enough to accommodate rapid changes in farming and forestry techniques.
- **Communication:** Limited awareness and misconceptions about sustainable practices can hinder progress.

Current Policies Countering Identified Drivers: The Czech Republic is in the process of reforming subsidy systems, making them more straightforward, and aligning them with sustainable objectives. There's also a push for enhancing collaborative frameworks between different stakeholders. Furthermore, training programs are being put in place, focusing on sustainable soil management and precision farming techniques.

Organizations with a Focus on Soil Health: Several agricultural and forestry organizations have prioritized soil health. They're now actively part of the governance structure, influencing policymaking and implementation processes. Research institutions, in particular, play a vital role in driving evidence-based policies and practices.

Public Awareness and Reaction: There's a growing public awareness of the importance of soil health, propelled by educational campaigns and increasing global attention to environmental issues. Local communities have started taking initiatives to promote sustainable practices, while the wider public is more receptive to policies that prioritize the environment. This public opinion is prompting organizations and governance structures to respond more proactively to soil health challenges.

Ongoing Transition Activities: Vysočina has been proactive in adopting transition activities that promote sustainable land use and soil health. Efforts to integrate precision farming, earth observation techniques, and sensor measurements are ongoing. The concept of measuring field or forest parcel attractiveness aids decision-making, allowing for more informed land management choices. Additionally, initiatives like citizen science projects engage the public, fostering a collective approach to improving soil health.

20.4 Conclusions

For an optimal soil health framework and a robust socio-economic fabric in Vysočina, a dedicated thrust on research and innovation is indispensable. The recent workshop shed light on pivotal areas like precision farming, earth observation, and sensor measurements, intertwined with the enriching potential of citizen science. A novel concept discussed was the quantification of the allure of fields or forest sections, which holds the promise to revolutionize decision-making for farmers and forest proprietors.

Incorporating precision farming through research and innovation has the potential to revolutionize resource utilization, nutrient absorption, and environmental preservation. By harnessing advanced technological tools such as real-time data sensors, farmers can craft informed strategies spanning irrigation, fertilization, and pest protection. This integration can bolster both soil vitality and crop yield.

Earth observation extends its scope by providing a macroscopic view of soil health, where remote sensing techniques deliver intricate details about soil moisture, nutritional profile, and plant vitality. This bird's-eye view, when juxtaposed with on-ground measurements, can create a detailed soil health matrix, aiding effective management interventions.

Sensor measurements pivot to real-time data, granting land managers the ability to consistently monitor and adapt to soil dynamics. Tools like moisture detectors and nutrient evaluators help streamline irrigation and fertilization, ensuring nutrient conservation and a tailored approach to the specific demands of the land.

Engaging the community through citizen science has the dual advantage of expanding the data network and fostering soil health awareness. By decentralizing data collection, not only is a wider spatial soil snapshot achieved, but it also instills a sense of responsibility and ownership in participants. This shared sense of stewardship can elevate the commitment to sustainable land use.

The innovative idea of measuring land's attractiveness provides an analytical lens for landowners. By weighing in variables like soil caliber, terrain, and infrastructure proximity, decisions can be better aligned with the land's inherent potential, ensuring both soil wellness and optimized yield.

To sum it up, the journey to impeccable soil health in Vysočina hinges on targeted research and innovation. Elements like precision farming, earth observation, real-time sensors, citizen-driven data, and land allure assessments collectively weave a future of improved soil practices and socio-economic vitality. By tapping into tech advancements, kindling community spirit, and anchoring decisions in data, Vysočina stands on the cusp of a future with sustainable land stewardship, thriving soil ecosystems, and robust agroforestry models. This orchestrated approach is not just a win for the environment but also a promise of socio-economic prosperity for Vysočina.

20.5 References

www.agrihub.cz/projects/prepsoil/

Regulation (EU) Nr. No 1306/2013 or 17 December 2013.
Regulation (EU) Nr. 1308/2013, or December 17, 2013.
Regulation (EU) Nr. No 1307/2013 or 17 December.
Regulation (EU) Nr. No 1305/2013 or 17 December 2013.
Act No. 254/2001 Coll.
Act. No. 252/1997 Coll.
Act. No. 326/2004 Coll.
Act. No. 334/1992 Coll.
The strategy of the Czech Ministry of Agriculture till the year 2030.
Nitrates Directive ND, EC 1991.
Regulation no. 137/1999 Coll., on Drinking Water Reservoirs and Drinking Water Protection Zones.
Czech Rural Development Programme.
Act no. 17/1992 Coll., on the Environment.
Act no. 114/1992 Coll., on Nature and landscape protection.
Act no. 183/2006 Coll., on the town and country planning and building code (Building Act).
Strategy on Adaptation to Climate Change in the Czech Republic.
National Action Plan for Adaptation to Climate Change.
Covenant of Mayors for climate and energy – Sustainable Energy and Climate Action Plan (SECAP).
Research of documents for the issue of drought and water management in the Southern Region.
Analysis of the negative impacts of drought and options for adaptation in the Central Bohemian Region.

21 Annexure 2: Common assessment procedures of the soil needs in representative regions across Europe

21.1 Introduction

The purpose of this document is to harmonize the PREPSOIL (www.prepsoil.eu) Work Package 2 methodology for the assessment of soil needs in representative land use regions across Europe for the PREPSOIL project (www.prepsoil.eu) Work Package 2. Representativeness is to be achieved by selecting regions based on NUTS2 information for selected soil properties, land use types, environmental zones, and socio-economic conditions. The interest in and access to stakeholder networks in different regions, as well as awareness within the regions for necessary transitions to improve and maintain soil health, are also factors that will be taken into account. Healthy soils are in good chemical, biological, and physical condition and are able to provide ecosystem services (EU Soil Strategy for 2030) for the purposes assigned through land use. Important to note is that the actual soil properties of a healthy (or unhealthy) soil differ based on the location, climate, and parent material the soil is formed in. Therefore, soil health challenges require a systems approach that understands soil as a living system, interfacing with water, air, ecosystems, human activities, food systems, landscapes, and other societal values (European Missions Implementation Plan, Keesstra et al., 2016). Healthy soils provide services to humankind as expressed in their biophysical as well as in their socio-economic contexts.

The definitions we use in the PREPSOIL project are:

- Soil H*ealth: the continued capacity of soils to support ecosystem services, assessed through a set of proposed, measurable indicators (SWD (2021) 323 final, p. 5).*
- *Soil Needs: the requirements from existing and emerging socio-economic and geo-biophysical perspectives that determine soil health and related services to human society.*
- *Living labs (LLs): spaces for co-innovation through participatory, transdisciplinary, and systemic research; specified soil health living labs: user-centered, place-based, and transdisciplinary research and innovation ecosystems that involve land managers, scientists, and other relevant partners in systemic research and co-design, testing, monitoring, and evaluation of solutions in real-life settings to improve their effectiveness for soil health and accelerate adoption" ecosystem services, assessed through a set of proposed, measurable indicators (SWD (2021) 323 final).*
- *Lighthouses (LHs): places for demonstration of solutions, training, and communication; best practice examples (technologies, cooperation, governance, trainings) that have already been developed and successfully applied.*

The assessment of soil needs is a first step in designing targeted research and innovation activities to improve soil health, for example, in the context of Living Labs (LL). The objective of PREPSOIL Work Package 2 (WP2) is to outline and conduct a soil needs assessment in a set of example regions across Europe to support future LL research and co-creation activities.

WP2 is a continuation of prior initiatives such as the Soil Mission Support (SMS) project. SMS developed both a systems framework for collecting knowledge needs on soil health at a European level (Löbmann et al., 2022) and a roadmap for Research and Innovation (R&I) needs from different actors and sectors to implement the soil mission (Ittner and Naumann, 2022). It also generated further initiatives, such as the SOILS4EU service contract that evaluated the importance of soils for societal challenges in Europe, the Norwegian Institute for Bioeconomic Research (NIBIO) report on soil threats in Europe (Tesfai et al., 2016), and the European Joint Program (EJP) on soil. In the PREPSOIL project, WP2 continues the work on soil needs, using a systemic approach with a high spatial resolution through the identification of soil needs at a regional level.

While identifying problems and challenges our soils are faced with, a systems perspective also incorporates the socio-economic and geo-biophysical dimensions. The focus on drivers simultaneously allows an anticipatory perspective with the set-up of strategic R&I needs while identifying potential regional LLs to address current soil needs.

In the assessment guidelines (provided in a separate document), the first chapter focuses on the framework used for structuring and coupling social and environmental problems—the DPSIR: Drivers, Pressures, States, Impacts, Response (EEA 1999)—and on the selection of around 21 representative regions across Europe. This document outlines approaches and methodological considerations for the Soil Needs Assessment in three steps: Step 1: a desktop study to acquire knowledge of each region for all elements of the DPSIR framework and make an inventory of the stakeholders; Step 2: interaction with stakeholders to (i) verify and discuss our desktop findings, (ii) get insights on their future vision, and (iii) discuss their perspectives on barriers and opportunities for transitions, including the possibility of Living Labs and lighthouses; Step 3: a summary of the soil needs for each region.

21.2 Methodological tools for a Soil Needs Assessment (SNA)

The guidelines apply to the land uses of agriculture, forestry, nature, urbanization, and industry. The goal of the SNA is to gain a holistic perspective with existing knowledge and describe the current state of affairs within the representative regions selected for PREPSOIL (Table 1). This will guide the three tasks that focus on different land uses (2.2 for agriculture, 2.3 for forests and natural, and 2.4 for urban and industrial). To facilitate the assessment in the selected regions, aggregated information on NUTS2 level is used as a starting point. In Annex 3, specific elements of the DPSIR are listed. They are a starting point for this desktop research.

The needs assessment, as defined in the introduction, relies on a systems approach. The assessment will start with a desktop study, followed by meetings with stakeholders to gather their views. In a third step, the collected information will be brought together.

The collection of this data is conducted by desktop research following a literature review of scientific literature, connecting existing knowledge from HORIZON (https://cordis.europa.eu/projects/en), LIFE (https://life.easme-web.eu/), and national research and implementation projects. The databases are provided by the European Commission.

21.3Steps

Step 1: desktop analysis of existing knowledge on drivers, pressures, states, soil health threats, and soil services demanded in the region (covering all DPSIR categories), as well as an initial inventory of all relevant stakeholders.

Step 2: stakeholder inclusive analysis, building upon knowledge acquired in Step 1, in which stakeholders will be asked for their opinion in a workshop and an additional ±10 targeted interviews.

21.3.1Step 1: Desktop study to assess all DPSIR elements in the regions

In each region, the 'region lead partner’ (see Table 1) will take the lead in finding the region-specific information in collaboration with the lead partners of the land-use tasks (T2.2: agriculture: CSIC, T2.3: forestry/nature: SLU, T2.4: urban/industrial: Deltares).

In Annex 2, available information is listed to construct a description of basic information for each region per land use type. Regional information will be collected and evaluated by the region lead partner (see Table 1). A region-specific database, oriented on the 8 objectives of the European Commission Soil Mission (based on information in Annex 2), will be constructed and communicated by PREPSOIL in the beginning of 2023.

Inventory of Drivers (D) and Pressures (P) in the regions

The following drivers and challenges should be taken into account:

1. Environmental drivers and challenges (e.g., climate change and related drought risk, flood risk, fire risk, frequency of extreme weather, biodiversity degradation, etc.).
2. Socio-economic drivers and challenges (e.g., social cohesion, cultural identity, economic outlook, structural changes in economic, demographic, social, cultural tissue, urbanization, tourism, consumption and dietary changes, norms and value changes).
3. Political and legal drivers and challenges (e.g., EU directives, national environmental, climate, and agricultural legislation, Green Deal objectives and related policies, regional development plans).
4. Technological and social innovations (e.g., new technologies, new business models, new cooperations, new value chains, industrialisation of agriculture and forestry and digitalisation of e.g. working processes/chains, paper work and communication paths).

The aim is to establish a common problem structure for the case study in the region, following the connection between Drivers and Pressures. Hence, the vital step in the analysis is to discover the links between drivers, the causes of pressures, and their effects. In other words, what are the causes (drivers) of a certain soil management practice (pressure) (Hamidov et al., 2018).

Inventory of current knowledge about the State and Impact of the Soil Needs in the region

- Biophysical information:
- Soil information:
- Soil type WRB classification:
- Dominant topsoil texture:
- Dominant soil threat:
- Land use management:

- Which measures for soil protection are currently used in the region

- Which specific land management practices exist in the three land uses present in the region

- Behavior of the dominant land use in the last decades

- Existing transformational activities in the region:
- Biophysical activities for specific land use or land management:

Inventory of the current socio-economic knowledge

  - Socio-economic information

        - Stakeholder groups: (general, more in phase 3)
        - Policy strategy:
        - Which policies affect the region (e.g., regional development plans, regulation on dominant land use, implementation of the EU Forest Strategy):
    - Existing transformational activities in the region:
- Socioeconomic activities for specific policy, governance, and local initiatives (local champions, Living Labs and Lighthouses:

Identifying key stakeholders

For the actor analysis, the region lead partner is responsible for setting up the stakeholder inventory in collaboration with ACTA (the responsible PREPSOIL partner for stakeholder management), together with task leaders and land use coordinators for agriculture (2.2), forestry (2.3), and urban and industrial land (2.3). The actor inventory of WP1 can be used.

In each selected region:

1. Identify key stakeholders

a. Agriculture:

Information will be extracted from existing bodies of stakeholders (EJP SOIL National Hub for agriculture), plus local stakeholders in the regions.

b. Forest/Nature

Information will be extracted from existing bodies (i.e., networks of our partner F-PCTEX for forestry). A review of soil needs and drivers of change will be complemented by dialogues with a broad range of stakeholder representatives, including the EU (DG ENV) and national and regional authorities, prioritized with the aim of covering regional differences across Europe and with a focus on the most pertinent challenges and needs. Local stakeholders in the regions will also be included.

c. Urban/Industrial

Information will be extracted from existing bodies and networks of stakeholders (such as the EU Nicole and Common Forum networks): ACR+ for urban and industrial land, plus local stakeholders in the regions.

The stakeholders that are suggested to be consulted may comprise of the stakeholder groups listed in Tables 2 and 3:

Table 21-1:Stakeholder categories according to PREPSOIL Dissemination, Exploitation and Communication plan

Civil society and citizens
Higher education institutes
Industries
Land user / manager / owner and their advisors
Middle and secondary schools
NGOs and associations
Other educational and awareness actors
Policymakers and government
Primary school
Research Community
Research Funders
Service providers
Soil advisors
Supply and retail actors
Vocational institutes

Table 21-2: Stakeholder bodies

(Potential) Living lab or lighthouse
Community of practices
National Contact Point
National Soil Hub
Soil ambassador

21.3.2 Step 2: Guidelines to the stakeholder interaction, interviews and workshops

The meetings/workshops and questionnaires are aimed to extract information on soil needs for the selected region from different stakeholder groups and are designed to be the most effective methodology for this specific stakeholder group. The guidelines will ensure comparability across Europe and land uses. However, methods may differ to be best suited for purpose.

Possible options for stakeholder interaction can be: workshops, interviews and questionnaires:

In person meetings/workshops: For in person meetings/workshop we suggest to invite:

- representatives of the different stakeholder groups in agricultural regions. Make use of the EJP SOIL national Hubs, but also invite other stakeholders that are specifically from this region.
- land owners / managers
- local champions (well-known person that is leading a transitional land management) (if available).
- local policy makers
- make sure different actor groups and land uses (where feasible) are represented

Aim of the regional workshops: Aim of the workshops is three-fold: i) verify our desktop results to come to a common understanding of the region's current situation; ii) gather future visions, with their barriers and opportunities, from stakeholders and iii) find possible entry points for Living Lab and Lighthouse development.

Focus group interviews/Workshop template (adoptable to partners need)

1. Summarize the information gathered in the desktop work (step 1)
2. Explain the DPSIR framework (ppt will be provided) if useful
3. Invite local stakeholders to present their current issues and work
4. Round the table (e.g. in the form of world cafe setting) to:
   a. reflect on the presented information from the desktop study (is it complete, correct, the right information/interpretation).
   b. ask for the stakeholders' future visions/desired future for the region
   c. discuss barriers
   d. identify opportunities for transition
   e. discuss trade-offs of visions/solutions
   f. identify options for Living Labs and Lighthouses in the region.

Interviews with key stakeholders:

For each interview we ask you to report on the following questions:

1. Which category each interviewed stakeholders belongs to, in order to make an overview of which type of stakeholder was interviewed for each task.
2. How do the results of the prioritization of the soil needs relate to:
    a. Environmental zone
    b. Soil threat/challenge/management
    c. Impact and role of policies
    d. Role of different stakeholders

Discuss these topics in line with the DPSIR questions (see table below).

In Annex 3 you can find the DPSIR elements you may use as a help and in Annex 4 you can find a list of questions that may be of help to structure your questionnaire, but this is by no means a list you have to follow.

NOTE: Include the PREPSOIL data policy and GDPR consent in the questionnaires and interviews.

You may find it challenging to cover all questions to all of your interviewees.

Please prepare each interview well and decide which questions are most relevant for each interviewee you have in front of you. Keep in mind the main objective: to identify the soil needs of each region, in the context of the DPSIR framework, as explained in these guidelines.

21.4 References

EEA Report, 1999. Environmental Indicators: Typology and Overview. https://www.eea.europa.eu/publications/TEC25

Helming, K., Daedlow, K., Paul, C., Techen, A.-K., Bartke, S., Bartkowski, B., Kaiser, D., Wollschläger, U., & Vogel, H.-J. (2018). Managing soil functions for a sustainable bioeconomy. Assessment framework and state of the Art. Land Degradation & Development 29(9), 3112-3126 https://doi.org/DOI: 10.1002/ldr.3066

Ittner, S., Naumann, S. (2022) A European roadmap on soils and land management. https://www.soilmissionsupport.eu/fileadmin/inhalte/soilmission/pdf/d_35_roadmap_v10-complete.pdf

Keesstra, S. D., Bouma, J., Wallinga, J., Tittonell, P., Smith, P., Cerdà, A., ... & Fresco, L. O. (2016). The significance of soils and soil science towards realization of the United Nations Sustainable Development Goals. Soil, 2(2), 111-128.

Löbmann, M. T., Maring, L., Prokop, G., Brils, J., Bender, J., Bispo, A., & Helming, K. (2022). Systems knowledge for sustainable soil and land management. Science of the Total Environment, 153389.

https://www.fao.org/soils-portal/data-hub/soil-classification/world-reference-base/en/

https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Glossary:Material_deprivation

Nougues, L., Brils, J., (Eds). (2022). SOIL AND LAND MANAGEMENT ONTOLOGY REFERENCE DOCUMENT. https://www.soilmissionsupport.eu/fileadmin/inhalte/soilmission/pdf/sms_d43_ontology_final.pdf

Panagos, P., K. Meusburger, C. Ballabio, P. Borrelli, C. Alewell. Soil erodibility in Europe: a high-resolution dataset based on LUCAS. Sci. Total Environ., 479 (2014), pp. 189-200

Orgiazzi, A., Panagos, P., Yigini, Y., Dunbar, M. B., Gardi, C., Montanarella, L., & Ballabio, C. (2016). A knowledge-based approach to estimating the magnitude and spatial patterns of potential threats to soil biodiversity. Sci Total Environ 545-546 (11-20).

Ronchi, S., Salata, S., Arcidiacono, A., Piroli, E., & Montanarella, L. (2019). Policy instruments for soil protection among the EU member states: A comparative analysis. Land Use Policy 82 p.763-780

Schjønning, P., van den Akker, J. J., Keller, T., Greve, M. H., Lamandé, M., Simojoki, A., ... & Breuning-Madsen, H. (2015). Driver-pressure-state-impact-response (DPSIR) analysis and risk assessment for soil compaction—a European perspective. Advances in agronomy, 133, 183-237.

SOILS4EU Contract for DG ENV (Service contract No 07.0201/2016/742739/SER/ENV.D.l, duration) https://www.deltares.nl/en/projects/soils4eu-importance-soils-societal-challenges-europe/

Tesfai, J., et al. (Editors) 2016. Soil threats in Europe. doi:10.2788/828742

Tóth, G., A. Jones, L. Montanarella. The LUCAS topsoil database and derived information on the regional variability of cropland topsoil properties in the European Union. Environ. Monit. Assess185 (2013), pp. 7409-7425

Tscherning, K., Helming, K., Krippner, B., Sieber, S., & Paloma, S. G. (2012). Does research applying the DPSIR framework support decision making? Land Use Policy, 29, 102–110. https://doi.org/10.1016/j.

22 Annexure 3: DPSIR elements related to the soil needs - Suggestions to guide your validation in the workshops

Table 22-1: :DPSIR Framework for the Soil Needs Assessment

DPSIR element	Soil needs	Information source/stakeholders to ask/involve
D(river)	SoilMission Objectives Climate change Societal changes/demand changes Demography Policy (changes) Technology development	Literature review Policy review (depending on land use/objective) Governance documents Industry/market information Analysis of future trends and driving forces for soil management
P(pressure)	Soil management	Definition of human activities exerting pressures on ecological system (soil management) Land use type and specification for each land use type (intensity; system) Agriculture: Livestock/arable/mixed/horticulture/agroforestry; intensity level (livestock density; fertilizer use; crop rotations); system: organic, conventional, regenerative. Forestry: managed forest (subdivisions); natural land Urban: monocentric, polycentric
S(tate)	Soil health needs	Soil health indicators for the soil threats Maintain/increase SOC Avoid Greenhouse gas emissions Avoid peat degradation Avoid soil erosion Avoid soil sealing Avoid salinization Avoid acidification Avoid contamination Optimal soil structure Enhance soil biodiversity

		Enhance soil nutrient retention/use efficiency Enhance water storage capacity
I(mpact)	Soil related ecosystem services needs (soil functions)	Water Storage & Regulation Primary Production of Food/feed/fibre Habitat for Biodiversity Nutrient Cycling Carbon sequestration and climate regulation Assessment and valuation of direct and indirect impacts in contexts of social, economic and environmental targets (SDGs) Analysis of the effect of human activities on the state of the ecological systems (soil processes and soil functions (soil processes are affected by soil management and describes how soil processes impact the ensemble of soil function.
R(esponse)	soil management needs soil policy soil literacy Policy in other policy areas protecting soils - regulating soil health	Land Management categories ● Agricultural systems diversification ● Disconnectivity of landscapes in terms of water and sediment transfers ● Land, water and nutrient management ● Value chain Policy needs ● Elaboration of governance and policy instruments ● Local science policy ● Soil literacy needs Stakeholder involvement ● Soil information ● Improved monitoring

23 Annexure 4: Questions repository

For the interviewer:

- **Introduce yourself, PREPSOIL and the objective of the interview and how results are used.**
- **Register names, organization, function of interviewee**
- **Ask for consent to use the data provided (https://gdpr.eu).**
- **Also ask everywhere if they have underpinning documentation/research/maps**

NOTE: *This set of questions is intended to help to structure the interview; to be able to retrieve the necessary data for compiling the report in step 3. A transcript of the interviews does not need to be reported to the coordinators of WP2, but a short summary of the key messages needs to be provided including the name of the organization of the interviewee (also to be included in the excel provide.*

Questions Drivers	Comments to question
What is the dominant land-use in your landscape/region?	Establish of common understanding of the conversation topic
What is the main purpose of this land-use?	Establish of common understanding of the conversation topic
Has the land-use changed in the last 50 years?	Ask for extension or shrinking, more intensive, accumulation of property rights? *Provide examples on official land use change maps and instead ask is this in line with your understanding /do you have a different understanding=?*
If so, how did it change?	
What has remained the same in that same time period?	Question aims at discovering that rate of change in this area
Has the production or main land management in this land-use changed?	Insert how production or land cover or method has changed? (Drivers)
To what do you attribute these changes?	Question aims at (external?) causes and drivers, reformulate if not understood)

What activity has had lead to this increase	If the answer is: land-use has been degraded due to activity XYZ – ask for specific activity that has had a negative or positive impact.
Have you noticed changes in weather patterns? Climate change effects?	
What subsidies do you receive from the EU/national government/region?	Explain subsidies in detail if necessary, give examples CAP, regional development plans, regulation of the government
Which regulation/law are you aware of that manages soils or land?	Think about it in terms of policy as driver/cause of behavior
Are you aware of new technologies/management strategies applied in this land-use (e.g. to improve production or reduce impact)?	Establish perception of (pre-existing) technological and social innovations as internal drivers (i.e. originating in the stakeholder network).
Pressures	
What changes have you noticed in the physical environment in and around this land-use?	Explore the Pressures felt due to the drivers discussed above.
How has this affected the way of managing the soil?	Specific Pressures in the shape of changes to land-use-related activities.
In what way did you manage the soil before?	Help put changes in context
When is the last time you made a change to your equipment / mode of operation?	
Under what circumstances did you make this change?	Additionally, if not understood: ask for financial changes, technological novelties

How regularly do you inform yourself about novelties in management practices?	Can be a scale question 1-10
What are the channels from which you receive information?	Name examples: newspaper, internet, where?
State	
How do you see that the state of the soil is now compared to earlier	If change: when and why did this change occur. Think of levels of: Soil organic matter Level Greenhouse gas emissions Level peat degradation Level soil erosion Level soil sealing Level Salinization Level acidification Level contamination Level water storage capacity Level soil nutrient retention Level of soil biodiversity Level of soil compaction (soil structure)
How do you think that these changes could be measured/monitored? (Which Indicators)	Find indicators which are applicable to the land use and region
Own assessment of the state of the soil	Can be qualitative after stakeholder’s perception. Or a scale from “unhealthy” to “healthy”
Impacts	
Ecosystem services	Provision of materials (sand, clay, gravel, rock) Soil related cultural services (incl. cultural heritage, archaeology, landscape) Provision of energy (ATES, geothermal, fossil resources) Provision of food, fiber and biomass Water purification (and soil contaminant reduction) Water flows regulation (incl. water/ discharge storage) Drinking water resources

	Carbon storage (incl. climate regulation) Support for biodiversity and nature Natural attenuation to soil contamination.
Climate change mitigation	Soil organic carbon sequestration, greenhouse gas emission reduction
Resource use efficiency	Water, land, energy, phosphorous, labor
Human health	Healthy environment, water, food (absence of pollutants), shelter, mental health, absence of disasters
Economic/social/rural development	?
Land use resilience incl. climate change adaptation	Robustness, adaptability, transformability - fit for future
Land use performance	In agricultural systems, income, revenue on farms, adaptability, transformability
Responses	
How would you like to see your region in 20 years from now?	
What would you need to reach the vision described in the previous question?	
What are the barriers you see for yourself and the surrounding society to reach the vision described above?	In terms of legal, economic, social, institutional, technical, communicational aspects
What policies do you find in place or preparation to counter the drivers that were identified?	

What organizations have the topic on their agenda?	Are they part of the governance structure? Do they influence the system?
Is there a public awareness and/or reaction to the drivers, pressures and impacts that were identified?	Public opinion as a response can trigger responses in organizations/governance.
Final questions	
Which research and innovation do you need to come to your future vision	
Which Living labs and lighthouses would you like to see set up or encouraged (if already there)	

24 ANNEX 4:Template for answering the "Common Assessment procedure for soil needs in representative regions across Europe"

Table 24-1:Regional Information template

Dominant land use:	
Secondary land use:	
Climatic Zone:	
Soil WRB classification:	
Soil type:	
Dominant topsoil texture:	
Soil threat(s):	
Stakeholders:	*Description of the main stakeholders in this region including their relation with each other (use link provided for full detail)*
Policy Strategy:	*Review of the main Policy documents on local, regional and national level (depending on availability) regarding the dominant land use **and** soils.*
Representative for regions in:	*Review of regions for which the dominant land use and the soil need also applies.*

25 Annexure 5: Reporting template for the soil needs assessment based on the Drivers, Pressures, States, Impact, Response (DPSIR)

Answers should touch upon the main active drivers in the region as outlined in the guidelines document. These may include: external trends and shocks, demand changes, degradation forces, involved stakeholders, natural processes, policy (etc.). The focus of the description should include the current situation **and** future expected developments.

Drivers **Biophysical driver(s):**Description of the main biophysical drivers in the region **and** a reflection on whether the biophysical driver is active in the future (e.g.2050**)** **Socioeconomic driver/issue:** Description of the main socio-economic activity in the region **and** a reflection (extrapolation) on whether the socio-economic driver is active in the future (e.g.2050).
Pressures *Suggestions to include:* Answers should touch upon the direct implications for soil management exerted by the drivers and answer what soil management needs arise from the drivers now and in the future. Description of the current pressures in the system and an extrapolation on the desired pressures in the future (e.g. in 2050)
State: Answers should provide adequate indicators for the soil health and well as determine their current levels in the dominant land use in the region (Determining the status of the soil health). Include maps and statistics
Problem statement of biophysical situation:Description of the main biophysical state in the region and soil management. ***Problem statement of socioeconomic situation:*** Description of the main socio-economic activity in the region in combination with its effects on soil and soil management. Description of the causes in the socio-economic system and their effects on soil and soil management
Impacts: Answers should touch upon the changes in the soil by the drivers, pressures and states and the consequences of these changes for the dominant land use.
Response: Answers should include the reaction of the societal system to identified impacts and how the responses may act as a driver themselves. This may include reflections on

changed management practices and their incentives, policy changes, changes in the dominant land use, ongoing transition activities in the region (Options for soil health, improvements, awareness, policy needs). Include: ● Future visions for different stakeholders ● Barriers ● Challenges
Conclusions: What are the target research and innovation activities needed to improve or maintain soil health and a viable socio-economic situation?

EUROPEAN MISSION SOIL WEEK

European Mission Soil Week

22 - 29 Nov 2023

Poll results

slido

Table of contents

EUROPEAN MISSION SOIL WEEK

Table of contents

Table of contents

EUROPEAN MISSION SOIL WEEK

Table of contents

Table of contents

Plenary - Main Hall (Building A)

Open text poll

EUROPEAN MISSION SOIL WEEK

Which country are you from?
(1/4)

103

- Italy
- Spain
- Spain
- Uk
- Colombia
- France
- Germany
- Spain
- Spain
- Ireland
- Spain
- Spain
- FRANCE
- Spain
- France
- Greece
- Norway
- Estonia
- Lithuania
- Belgium
- Netherlands
- Dk
- Spain
- Hungary
- Spain
- Slovakia
- Based in Germany
- Poland
- Spain
- UK

slido

Open text poll

EUROPEAN MISSION SOIL WEEK

Which country are you from?

(2/4)

1 0 3

- Finland
- Greece
- Spain
- Belgium
- Greece
- France
- Spain
- China
- France
- Estonia
- Spain
- Spain
- UK
- Germany
- Denmark
- Greece
- Italy
- Spain
- Romania
- Spain
- Greece
- Spain
- Denmark
- Sweden
- Lithuania
- Ukraine
- Italy
- Luxembourg
- France
- France

EUROPEAN MISSION SOIL WEEK

Which country are you from?
(3/4)

103

- SPAIN
- Italy
- Spain
- Ireland
- Finland
- France
- Spain
- Latvia
- France
- France
- I am based in Denmark
- Latvia
- Portugal
- Belgium
- Denmark
- The Netherlands
- Spain
- Spain
- Italy
- Belgium
- France
- Finland
- Spain
- France
- Denmark
- The Netherlands
- France
- NORWAY
- Netherlands
- Spain

EUROPEAN MISSION SOIL WEEK

Which country are you from?
(4/4)

103

- Ireland
- Finland
- Spain
- Germany
- Netherlands
- Germany
- United Kingdom
- Italy
- Belgium
- Finland
- estonia
- Italy
- Spain

Multiple-choice poll

EUROPEAN MISSION SOIL WEEK

Which land use are you most interested in?

117

Agriculture — 48 %

Urban — 15 %

Forestry — 11 %

Mixed — 26 %

Other — 0 %

slido

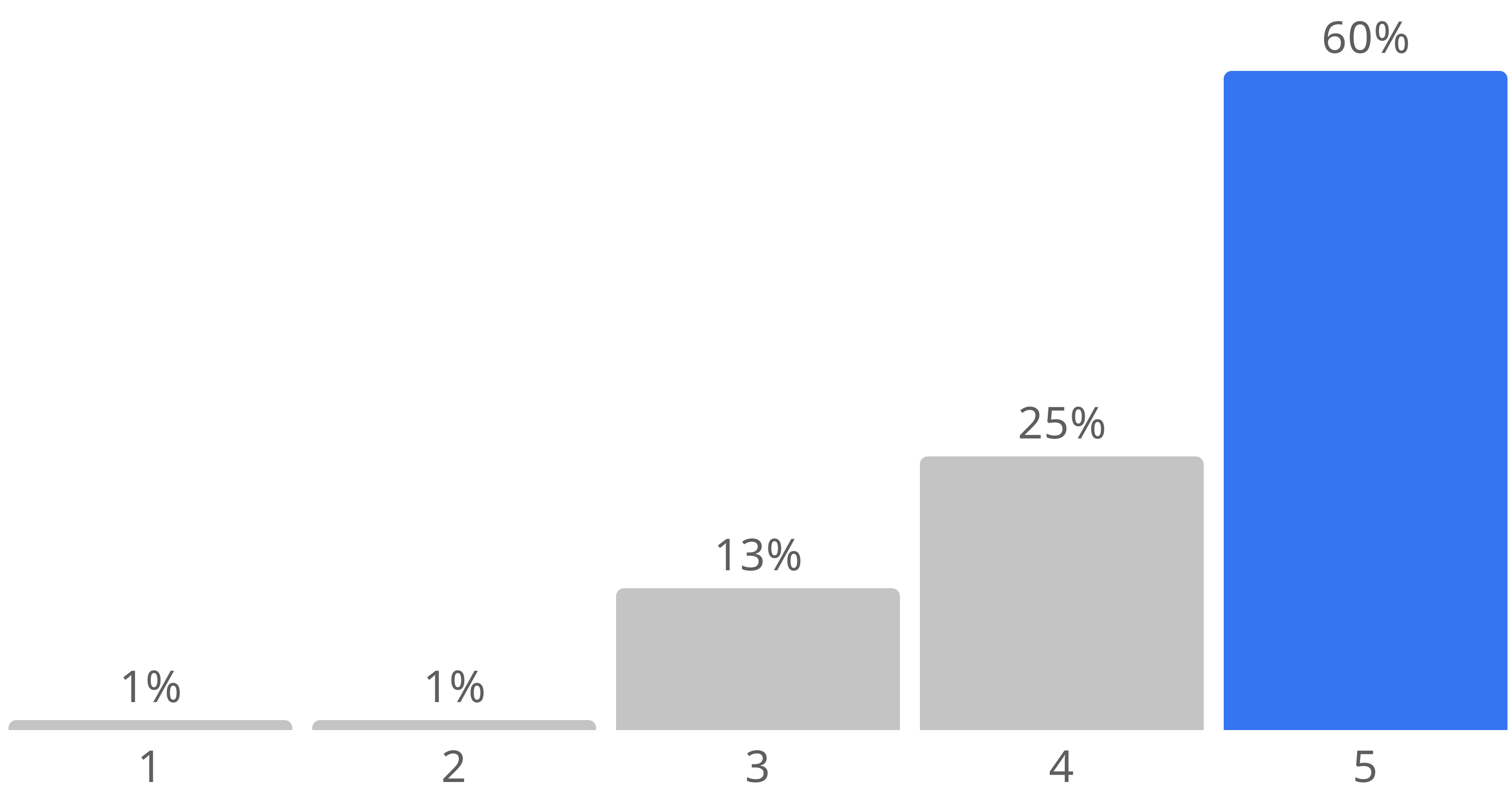
Rating poll

EUROPEAN MISSION SOIL WEEK

Do you agree with the presented statement about the main soil needs for urban areas?

097

Score: 4.4



slido

Open text poll

EUROPEAN MISSION SOIL WEEK

Which other solutions would you suggest for urban areas?

(1/4)

079

- Monitoring
- De-sealing events that involve the public
- Involving citizens and practitioners in decision-making process
- Soil occupied managament policies
- Desealing
- Participatory research and action
- Building gardening
- Regenerate with recycled materials
- Technosoils
- Teleworking
- Revegetation
- Greening cities
- Greening city
- Trees
- Better public engagement
- Irban composting initiatives
- Citizen participation
- Soil quality assessment for all city gardeners
- Ungentrify
- soil monitoring
- Awareness in soil based ecosystem services

slido

Which other solutions would you suggest for urban areas?

(2/4)

079

- Gardening
- Regeneration
- Risk based remediation and land use
- Nature
- Circular soil and land use
- Urban gardening
- Gardening
- Circular waste
- Trees
- Soil monitoring gone public
- Circular economy for soils.
- Develop partipatory processes. HUMUS methodology
- Monitoring
- Preserve soil
- Analyse all soil types within city
- Nature based solutions
- Urban agriculture
- Add amendments
- De-sealing
- deseal and regenerate
- trees
- Tecnosols
- Revegetation
- Relistic & pragmatic risk assessment of soil chemical pollution

Open text poll

EUROPEAN MISSION SOIL WEEK

Which other solutions would you suggest for urban areas?

(3/4)

0 7 9

- Benchmarking with other cities
- System approach Community building
- Community-wide based monitoring
- Phytoregeneration
- River landscape management
- Connect urban planificación, environment and human health
- Greening cities
- Nature based Solutions
- Soil monitoring - evaluation - planning
- Revegetatiom
- Involve and make develops + businesses uses the spaces engaged in the process
- Smart desealing
- More green surfaces
- More holistic land use planning
- Soil monitoring
- Urban gardening spheres (eg. roofs)
- Include school Projects
- Circular waste
- Nature based solutions
- Raise awareness
- More public greenspaced

slido

Open text poll

EUROPEAN MISSION SOIL WEEK

Which other solutions would you suggest for urban areas?

(4/4)

079

- Green areas
- Urban agriculture
- Tecnosols
- greening cities
- Funding and policies
- desealing
- Policy Learning
- Soil monitoring
- Technosoils
- Revegetation
- Innovation on housing
- Inventory of polluted sites
- Reduce density
- Soil engineering
- Place based solutions and Education
- Role of urban food production
- Tecnosols
- Debelop parricpatory processes
- Greening cities
- Soil monitoring
- Less totally sealed areas
- Ban Airbnb
- Gardening
- Tecnosols

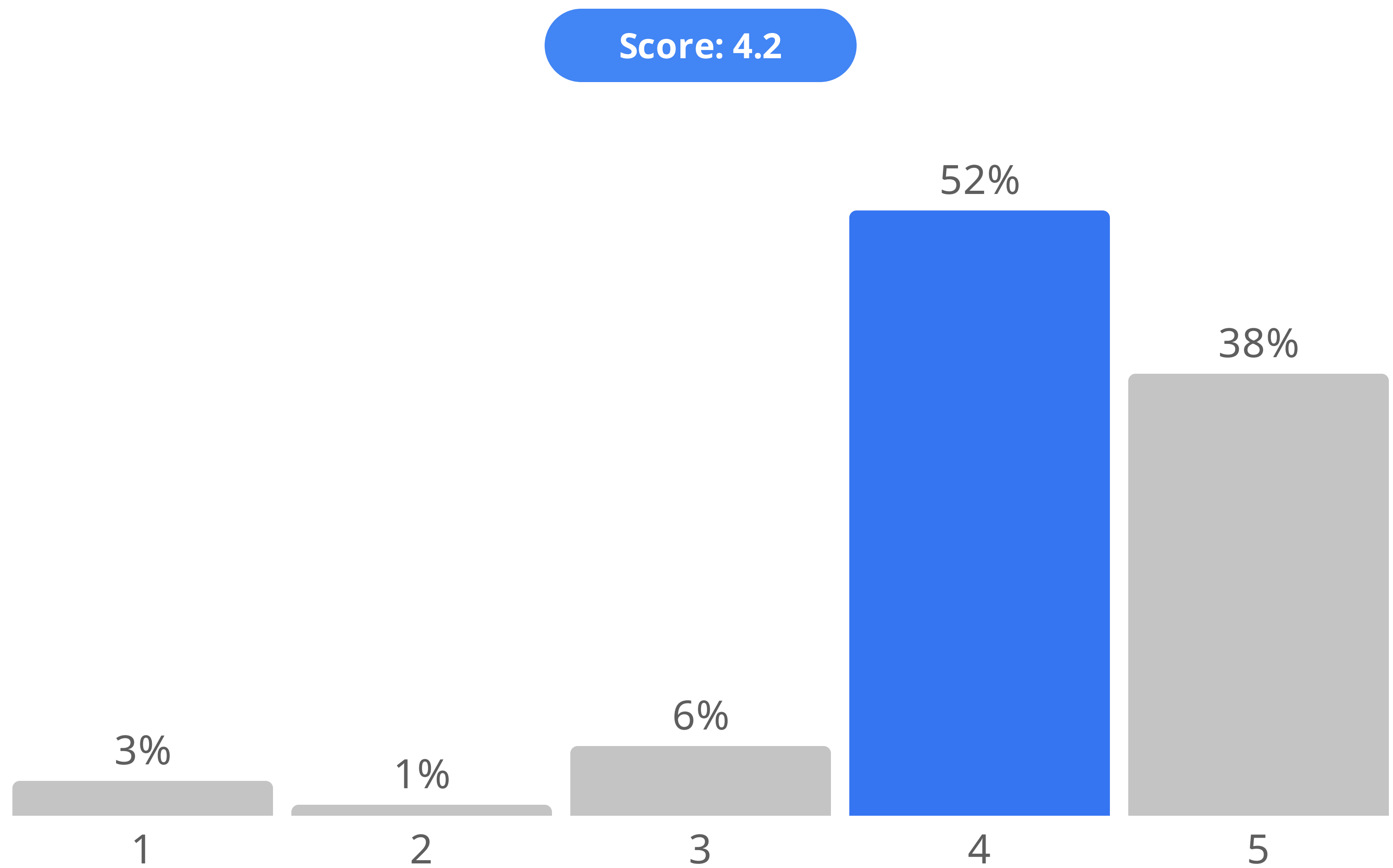
slido

Rating poll

EUROPEAN MISSION SOIL WEEK

Do you agree with the presented statement about the main soil needs for forestry?

1 0 0



slido

Which other solutions would you suggest for forestry?
(1/5)

0 7 1

- Renaturation
- Invest in the cultural heritage as well by reviving the cultural traditions that might be there
- Rewilding
- Increase awareness
- Rewilding
- Protection of ALL natural forests
- Rewetting
- Encourage eco tourism
- Use degraded soils to plant more wood land
- Assess ecosystem services coming aling with rewetting
- Rewilding
- Eco tourism
- Pollard and coppice closer to towns
- Awareness raising on forest values
- Awareness raising
- Saveguard local knowledge of forest management
- Rewilding
- Rewilding
- Sustainable management
- Monitoring
- Co- creation

Open text poll

EUROPEAN MISSION SOIL WEEK

Which other solutions would you suggest for forestry?

(2/5)

0 7 1

- Intelligent system for production and environment together
- Participatory policy
- Paludiculture
- “Let nature be nature”
- Connection solutions urban-forest-river. Protection of riverbanks
- Better understanding of soil condition under trees
- Alternative forest products
- Pristine forest
- No draining
- Rewilding
- Increase biodiversity based in nature
- Increase biodiversity
- Diversification of species
- Address dependence on low quality biomass in forestry (for paper)
- Better understanding of how different organisms in forests communicate amongst each other.
- Ecotourism
- Mapping carbon uptake of different types of vegetation

slido

Open text poll

EUROPEAN MISSION SOIL WEEK

Which other solutions would you suggest for forestry?
(3/5)

0 7 1

- Non-timber products
- Renaturate forests to learn about adaptabiliy to climate change
- Empower the farmers
- Soil management and monitoring
- Multiprofissional forests
- Develop business models to maintain the soil health in the long term
- Investment
- More dialogue with land owners
- Ecosystem service
- create awareness by coocreation of solutions
- Ring the trees and let them die and fall down
- Leave some are totally untouched
- Continuous growth / harvest? Several different tree species?
- Buodiversity
- Improve eco-tourism activities
- Monitoring
- Reforestation with native trees
- Monitoring
- Planning
- Invest on eco tourism and on reintroducing pristine forest. Also use

slido

EUROPEAN MISSION SOIL WEEK

Which other solutions would you suggest for forestry?
(4/5)

0 7 1

forestvascan educational site for the working of your specific wetland system

- Funding for private ownership stewardship
- Biodiversity
- Continuous cover forestry on drained peatlands Restoration of high BD areas Water management (ditch blocking) of drained forest areas
- Community building
- Policy lessons shall be upscaled
- Plant biodiversity
- Land use/ land cover monitoring
- Coppice
- Alternative forest products
- Prioritize your ambitions
- New species introduced
- Biodiversity
- monitoring sites
- Soil biodiversity
- Monitoring
- Forrest services onboard
- Ecosystem services
- Start locally
- Soil monitoring
- Reduce monocolture

EUROPEAN MISSION SOIL WEEK

Which other solutions would you suggest for forestry?

(5/5)

0 7 1

- Reduce bureocracy
- Instead of building consensus, could you develop a participatory process to design the measures from the beginning including a participatory diagnosis?
- Eco tourism
- Improve management control
- Advisor service
- Create ownership
- Sustainable management
- Co-design with local communities to maximise coherency and efficiency
- Protection
- Soil biodiversity map
- Diversified land use (paludiculture)
- Include soil biodiversity

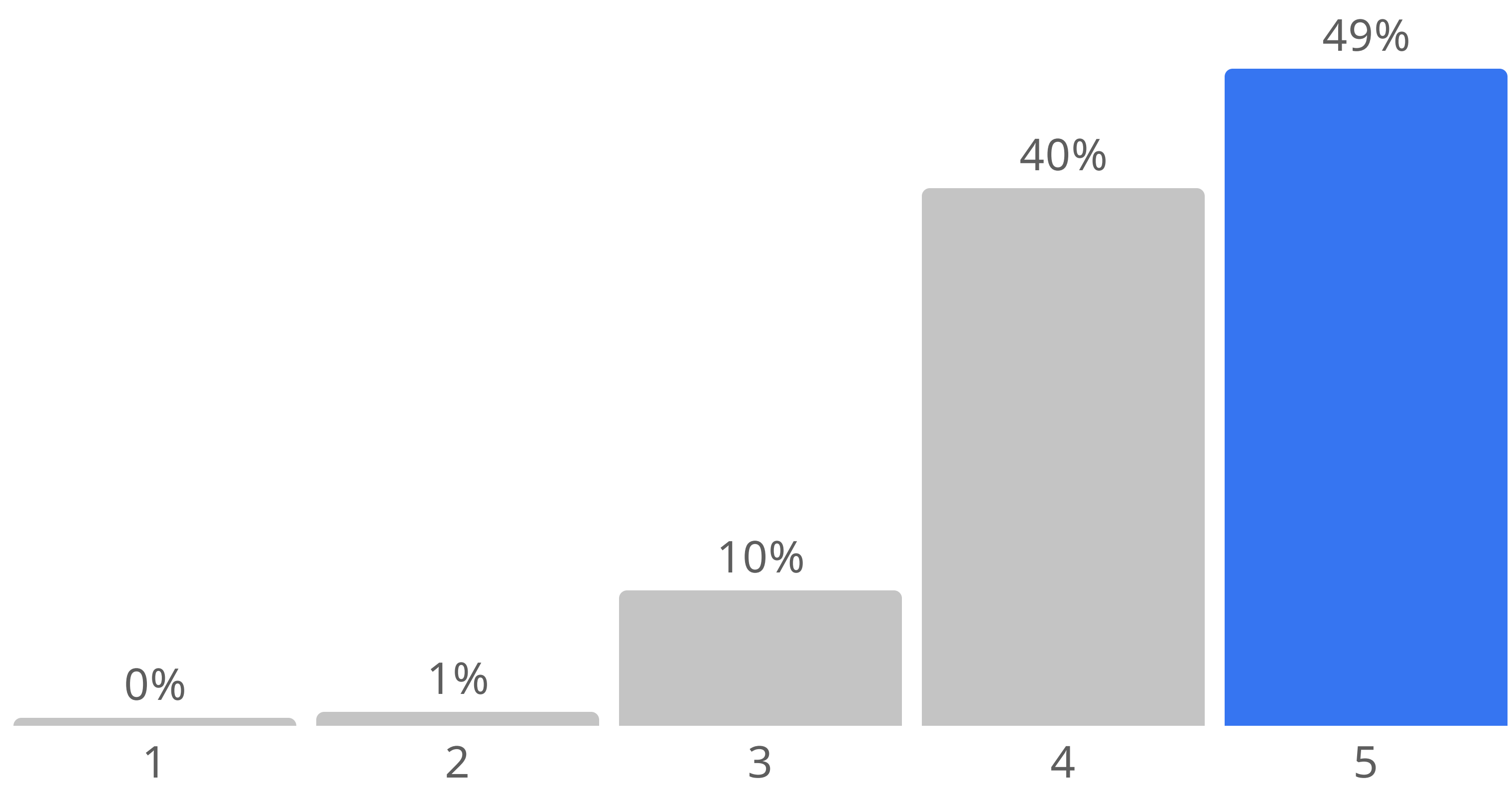
Rating poll

EUROPEAN MISSION SOIL WEEK

Do you agree with the presented statement about the main soil needs for agricultural areas?

0 9 0

Score: 4.4



slido

Which other solutions would you suggest for agriculture?

(1/4)

061

- afforestation
- Multicropping
- Legumes
- Biochar would be interesting to try.
- Agroforestry
- Regenerative narative agricultural practices
- Legumes
- Swales
- Introduce minor crops
- Swales
- agroforestry combination
- Increase value of agricoltural products for farmers
- Small ponds across landscape
- Organic amendments
- Organic fertiliser digestate
- Permaculture
- agroforestry
- Capacity Building in regenerative farming
- Très diversity
- Encouraging enhanced compost with high fungal presence. Adopt circular management and add organic amendments
- Grazing, water accumulation systems

Open text poll

EUROPEAN MISSION SOIL WEEK

Which other solutions would you suggest for agriculture?
(2/4)

0 6 1

- Develop eco-tourism to alliw News value chains for farmers
- Keyline system
- Windbreaks
- Hear from farmers what is really needed in the local context...
- Enable farmers as agents of change
- Create projects
- Citizens awarenes
- ponds?
- Plant trees and hedges
- Replicate this type of community engagement processes to empower farmers communities
- constructed wetlands
- Diversity
- Awareness
- Agroforestry
- Dig swales
- Stabilized amendments
- Hydropony
- Soil amendments
- Land use change
- Ponds
- Working closer with farmers
- Minor earthworks
- Knowledge sharing/learning with other similar regions/areas

Open text poll

EUROPEAN MISSION SOIL WEEK

Which other solutions would you suggest for agriculture?

(3/4)

0 6 1

- Codesign with farmers to better understand their needs, and training and educating how to make a change
- Applying circular fertilisers such as digestate
- Nature based solutions to recover rainwater
- Agroforestry
- Restoration
- Use of mycorrhiza
- Biochar
- Pedoclimatic regions specific solutions
- Citizen involvement
- Keyline
- Soil amendments
- Showcasing existing solutions
- Grazing introduce animals
- Small scale farming
- Agroforestry, plant hedgeros etc to improve microclumate
- Introduce ponds
- Muching
- Agroforestry
- Farmers need Social security and financial support
- Permanent cover

slido

Open text poll

EUROPEAN MISSION SOIL WEEK

Which other solutions would you suggest for agriculture?

(4/4)

0 6 1

- Intertwine with agroecology to increase water content in soils.
- Increase crop diversity
- Consider the soil-water nexus
- Intercropping
- Agroforestry
- Land use change
- Keyline !!
- Abandonment
- Improve soil biodiversity
- Biochar based soil amendments
- Improve advisory services
- Implement swales
- Landscape management
- Grazing and agroforestry
- Biochar

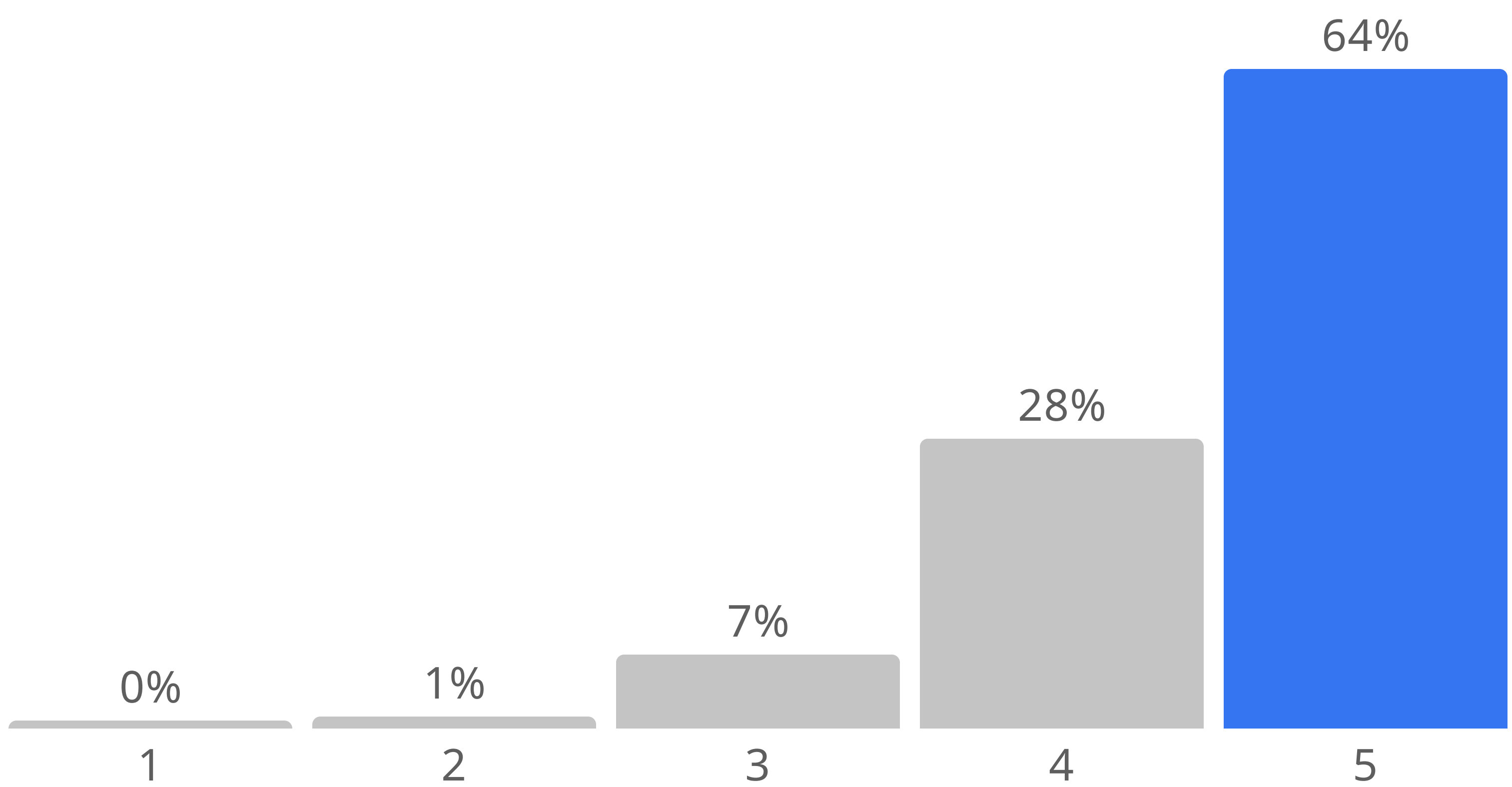
Rating poll

EUROPEAN MISSION SOIL WEEK

Do you agree with the presented statement about the main soil needs for mixed landuse areas?

083

Score: 4.5



slido

Which other solutions would you suggest for areas with mixed land use?

(1/4)

0 5 7

- Economical incentives for diversifying crops
- Consumer custom chamge
- Encourage infiltration of rainwater
- Disclose ecosystem services
- Combine with truffels
- Yeomans
- Differents livestock. (species)
- Involving comercial stakeholders, valuing the product as a high quality product thatwouldnt exist without the enviroment supporting it
- Over generational discussion between farmers.
- Diversified production
- Gather stakeholders from all land uses concerned and make them talk and make decisions together
- Opportunities for new settlers - access to land for those wanting to farm in the extremaduran way
- Regional government to help dehesa farmers assign the right price (and prepare the market) to pay fair price for meat, such to halt the trend in increased livestock breeding

EUROPEAN MISSION SOIL WEEK

Which other solutions would you suggest for areas with mixed land use?

(2/4)

057

- Eco-tourism promotion
- New Consumer customs - eating less
- Education
- Small earthworks
- Putting environmental needs first
- introduce mushrooms
- Payments to farmers/land managers who work in very remote areas to help maintain rural populations
- Farmers cooperative
- Stakeholders, involve local community
- More trees, more legumes, more agroforestry
- Reduced grazing density
- less bureaucracy
- Regional government support
- Certificate?
- Use as awarness raising location: educative activities
- perennial cereals
- Water basins
- Balanced livestock
- Increase tourism
- Participatory approaches
- Education

EUROPEAN MISSION SOIL WEEK

Which other solutions would you suggest for areas with mixed land use?

(3/4)

057

- Promote livestock breed adapted to the local context
- Better land management
- consumer involvement - KM0
- Manage Landscape diversity
- Supoprt agroforestry by labelling of products
- Rotative livestock
- Holistic pasture management
- Communication of value
- Less beurocracy on Animal husbandry
- Green cover
- Soil organic matter increase programs
- Reuse of organic wastes as compost, biochar...
- Agroforestry
- Different native cattle species
- Samrt farming
- Quality products
- Enable citizens to understand that livestock management is essential for most agro ecosystems to manage our natural and biodiverse habitats
- Demonstration farms
- Wait for gen. z people
- Eco-turism

Open text poll

EUROPEAN MISSION SOIL WEEK

Which other solutions would you suggest for areas with mixed land use?

(4/4)

057

- Livestock density
- New drought resistant grass species
- Planting trees
- Green cover
- Keyline
- Stakeholders engagement
- Smart farming
- Consumer involment
- Social awareness
- Less stricte animal register
- Quality products
- Balance Livestock density
- Tourism
- Razionale Pasture Voisin
- Swales

EUROPEAN MISSION SOIL WEEK

Based on your own experiences, what do you think are the three most important hindrances or bottlenecks to improve soil health in society? (1/9)

0 9 6

- Soil is a means not an end and gets warn out through use. People are more interested in ends and products.
- More urgent problems
- Citizens engagement
- No possibility to car for soil and make a living
- Curriculum overload
- Rules of the legislation sometimes incoherent
- Lack of understanding about the importance of soils
- Legislativo and lack of knowledge in innovative management
- Make soils more visible: linking soil health to human health
- lack of science-based education
- Exploitation of natural resources and humans as the basis of social order
- Good educational programme
- Moral values carring for yourself
- Soil in private hands
- Teaching On food and heslth instrac of pure biology
- People learn very little of soils

EUROPEAN MISSION SOIL WEEK

Based on your own experiences, what do you think are the three most important hindrances or bottlenecks to improve soil health in society?

(2/9)

0 9 6

in schools. People don't understand how long soil pollution stays in the ground. People don't care about soil.

- Time
- Lack of appreciation for farmers or producers
- Too many issues for people and schools to deal with.
- People do not appreciate how dependent we are on soil We have to integrate the knowledge available about soil
- society don't see soil as crucial as other environmental compartmenta
- Lack of information about soil importance
- too many historical pollution, buildings, ...
- Soil as dirt
- Capitalism
- Communication
- Importance of soil health is not understood
- Lack of community and solidarity econonomics
- Lack of understanding

EUROPEAN MISSION SOIL WEEK

Based on your own experiences, what do you think are the three most important hindrances or bottlenecks to improve soil health in society?

(3/9)

0 9 6

of the importance and consequences of poor soil health

- Responsibility
- Capitalism
- Lack of clear messages
- Education
- Soil science communication too comolicated
- Incoherency between soil protection and urban and industrial planning policies and public speeches
- Soil is seen as something nasty
- Human ignorance
- Capitalism
- Lack of formation of the teachers
- Individualism
- Knowledge
- Gap between research and general society
- Law makers lack interest and lack of literacy
- political priorities
- Private land ownership
- Awareness of decision-makers that need to be convinced that this is a priority, with benefits beyond soil preservation

EUROPEAN MISSION SOIL WEEK

Based on your own experiences, what do you think are the three most important hindrances or bottlenecks to improve soil health in society?

0 9 6

(4/9)

- Human Disconnection from nature/soil
- Capitalism
- Awarness
- soil health not obvious
- Lack of knowledge
- Lack of awareness
- Visibility
- School pensum
- Money in agriculture
- Interest Money
- 2. Polluters pay principle 3. Active role and

accountability of public authorities in good soil management

- Take time !
- Economy, profitability, lack of sensity
- Communication
- Biocides and industry
- Tradicional farming mindset
- Lack of awareness in the society
- Capitalism
- Sharing the risk of applying new practices between society and land manager

EUROPEAN MISSION SOIL WEEK

Based on your own experiences, what do you think are the three most important hindrances or bottlenecks to improve soil health in society?

(5/9)

0 9 6

- Education
- Not finding sense in which society hear
- Distance urban culture and rural culture
- Lack of knowledge
- Education
- Ownership/jurisdiction/responsibility of damage and improvements
- Lack of knowledge Lack of political awareness Lack of dialogue between all stakeholders (including citizens and public authorities)
- Drive change in farming practices eg by policy, intrinsic drive at farmers
- Awareness - many citizens do not realise soils is a living ecosystem
- Exploitation as the basis of the economic system
- lack of knowledge on soil importance, slow regeneration
- *Microorganisms are stills seen as pathogenic when just a very little fraction are
- Capitalism
- Soil investments in the local policy

Open text poll

EUROPEAN MISSION SOIL WEEK

Based on your own experiences, what do you think are the three most important hindrances or bottlenecks to improve soil health in society?

(6/9)

0 9 6

- Capitalism
- No teaching On food and soil in schools
- Making the soil interesting, using the cotton under wear test
- Education
- Soil is not apreciated
- Socialism
- Involucration os stakeholders
- Capitalism
- Insight in what the vale is of soil health
- Willingness for personal comfort
- Lack of priority
- Lack of knowledge about the importance of soil health
- Lack of interest
- The CAP
- Lack of education in soil in schools
- No sensorial access to the underground beauty
- Soil not obvious to public
- Soil is overseen
- Common message at all level
- Short term interests
- Capitalism

slido

EUROPEAN MISSION SOIL WEEK

Based on your own experiences, what do you think are the three most important hindrances or bottlenecks to improve soil health in society?

(7/9)

0 9 6

- Trade offs with yield
- lack of sanctions
- Funding
- Soil literacy
- Science communication
- Awareness
- Curricula
- Increase awareness
- Blind Capitalism
- Diets
- Capitalism
- Lack of interest
- School programs
- Soil literacy
- Interest
- Unawareness
- Economical reasons
- Value in agriculture
- Complexity
- Industry
- lack of knowledge and interest
- soil health understanding among the community
- NO AWARENESS OF THE PROBLEMS
- Lack of awareness

EUROPEAN MISSION SOIL WEEK

0 9 6

Based on your own experiences, what do you think are the three most important hindrances or bottlenecks to improve soil health in society?

(8/9)

- invisible soils
- Education
- NIMBY
- lack of knowledge
- Legislation
- Actionable knowledge transfer
- Lack of interest
- Capitalism
- Soil literacy Soil awareness Consumer involment
- Knowledge - awareness
- Industrialization of agriculture
- Little awareness of ecosystem functions
- Transdiciplinary collaboration
- Habbits
- A lack of understanding from academia on how farmers, land managers will take up good practices.
- Attitudes
- lack of knowlage
- Difficult to make it visible
- Visualization
- Knowledgebase
- Agrochem
- Clear messages

Open text poll

EUROPEAN MISSION SOIL WEEK

0 9 6

Based on your own experiences, what do you think are the three most important hindrances or bottlenecks to improve soil health in society?

(9/9)

- Lack of awareness
- Lack of knowledge
- Lack of interest in science
- Maintain agricultural yields
- Awareness

slido

EUROPEAN MISSION SOIL WEEK

What measures would you suggest to address these hindrances or bottlenecks?

(1/2)

0 3 5

- Use of videos, social media. More implication in educational programs
- Putting environmental issues first
- Training of educators and teachers
- Prepare material for teachers in bational language
- Communication and education
- Schools, education
- Education at early age
- Make community economies the norm
- Soil microscopy
- Coherence in public speech
- Tô teach children about soil
- include soil topic in school curriculum
- Education
- Start with food
- Combine
- Stop agrochem lobby
- Communicate better to the broader audience
- Continued inclusion of society in projects
- Training and education
- Demonstration

EUROPEAN MISSION SOIL WEEK

What measures would you suggest to address these hindrances or bottlenecks?

(2/2)

035

- Effective communication among stakeholders
- Reform CAP
- Education
- Incentives
- Make soil visible
- Carrying for others
- Direct contact with soil
- education
- Training, education, awareness raisimg
- Education
- Education
- Change legal system of land ownership
- Education
- Legislation
- Educational
- Raising awareness
- Education

Multiple-choice poll

EUROPEAN MISSION SOIL WEEK

What kind of organisation do you work at

120

Policymakers and governances

22 %

Research communities

54 %

Land owners and users

3 %

Industries and private sectors, Services providers, consultancy

16 %

NGOs

3 %

Other

3 %

slido

Multiple-choice poll

EUROPEAN MISSION SOIL WEEK

Have you signed the Mission Soil Manifesto yet?

0 9 2

Yes

42 %

Not yet

58 %

slido

Multiple-choice poll

EUROPEAN MISSION SOIL WEEK

100

What's the priority to achieve healthy soils for you?

(1/2)

Reduce land degradation relating to desertification

16 %

Conserve and increase soil organic carbon stocks

13 %

Stop soil sealing and increase reuse of urban soils

3 %

Reduce soil pollution and enhance restoration

16 %

Prevent erosion

2 %

slido

Multiple-choice poll

EUROPEAN MISSION SOIL WEEK

What's the priority to achieve healthy soils for you?

(2/2)

100

- Improve soil structure to enhance soil habitat quality for soil biota and crops — 26 %
- Reduce the EU global footprint on soils — 7 %
- Increase soil literacy in society across Member States — 17 %

slido

Open text poll

EUROPEAN MISSION SOIL WEEK

What can/will you do to protect soil?
(1/5)

0 8 6

- Convince farmers
- Raise awareness
- Plant hedges in thelandscape
- Engage municipalities
- Value farmers more
- Continue research and communicate on this topic. Challenge my friends to take good care of soil
- Raise the awareness on the role plants
- Offer security to the landowners
- Financiation for farmers
- Emphasise the importance of the international dimension
- Biodiversity and carbon research, co-creation of projects, buy from CSA
- Mission soil manifesto
- Communicate more , introduce best practicse
- Spread the word on soil health relevance
- To get the Soil Monitoring Law approved and implemented
- Monitor, communicate
- Reserch
- Recycling
- teach kids about the importance of heathy soils!

slido

EUROPEAN MISSION SOIL WEEK

What can/will you do to protect soil?

(2/5)

0 8 6

- Work together with stakeholder
- Enthuse people about soil
- KNOW IT BETTER AND HANDLE IT PROPERLY
- Inform coleagues
- Provide information data and training
- Raise awareness
- Evangelise
- Divulgativo and communication
- Promote an structured advisory service to farmer
- Research and disseminate the culture of soil health
- Organic food
- Eat more plant-based food
- Understand their processes
- Speak about soil health
- Reduce traffic impact Use cover crops
- Plant a real garden
- Promote the mission calls
- Teaching about soils
- Improve messaging
- To fully understand the ecosystem services they provide
- Environmental education
- SIGN THE MANIFESTO
- Tell the story of soil health and one health

EUROPEAN MISSION SOIL WEEK

What can/will you do to protect soil?
(3/5)

0 8 6

- Choose more organic food options
- Research
- Spread the word
- Connect with stakeholders (farmers, land owners, investors...)
- Responsable consumption
- Communication
- Share successfull stories
- MRV
- Change consumer habits
- Educate about Soil Health
- incentives
- Apply stabilized amendments
- Get all stakeholders behind a healthy soil strategy
- No till- Bio farming
- Fight for ecosystem services
- Stakeholder involvement
- Advise to farmers regenerative practices
- Organise the next Mission Soil Week 😊
- Recycle, invest and educate
- cut out soil-harming subsidies
- Manage the soil carefully
- Dont plant eucalyptus in arable land in Galicia, Spain
- Improve methods

EUROPEAN MISSION SOIL WEEK

What can/will you do to protect soil?
(4/5)

0 8 6

- Provide information
- Help to farmers
- Spread the word
- Communication
- Raise Knowlwdge and awareness
- Regeneration principles
- Comunícate aborto it
- Show the importance of soil
- Raise awareness
- ¡¡Citizen science and stakeholder engagement!!!
- Reduce waste
- Research and education.
- Buy more certified organic food
- Realistic risk assessment of soil chemical pollution
- Reclycle
- Increasing literacy around me
- Educate, communicate
- Improve access to data for better awareness
- MRV
- Research
- Develop methodologies
- Compost making
- Ambassador
- Comunicate more with citizens
- Spread the word
- Human compost
- Stakeholder engagement

Open text poll

EUROPEAN MISSION SOIL WEEK

What can/will you do to protect soil?
(5/5)

0 8 6

- Provide information
- Give it a new life
- Harmonise data
- Promote agroecology!
- Invest in organic

slido

Multiple-choice poll

EUROPEAN MISSION SOIL WEEK

What land use type do you manage/work with?

080

Mostly agriculture

56 %

Mostly Urban

10 %

Mostly Forestry

1 %

A mix

33 %

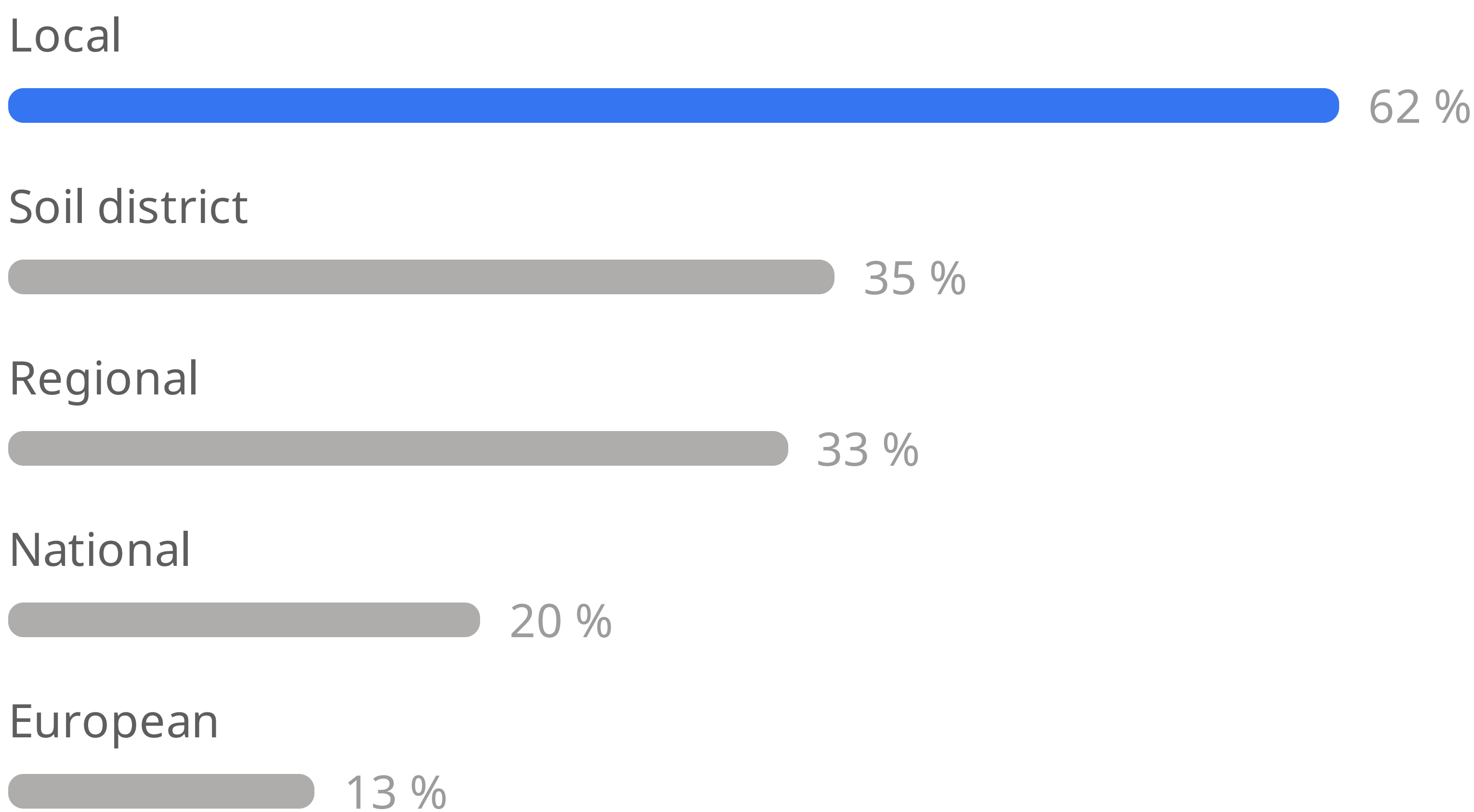
slido

Multiple-choice poll (Multiple answers)

EUROPEAN MISSION SOIL WEEK

At what spatial scale would a soil health assessment be of most help to you?

0 9 8



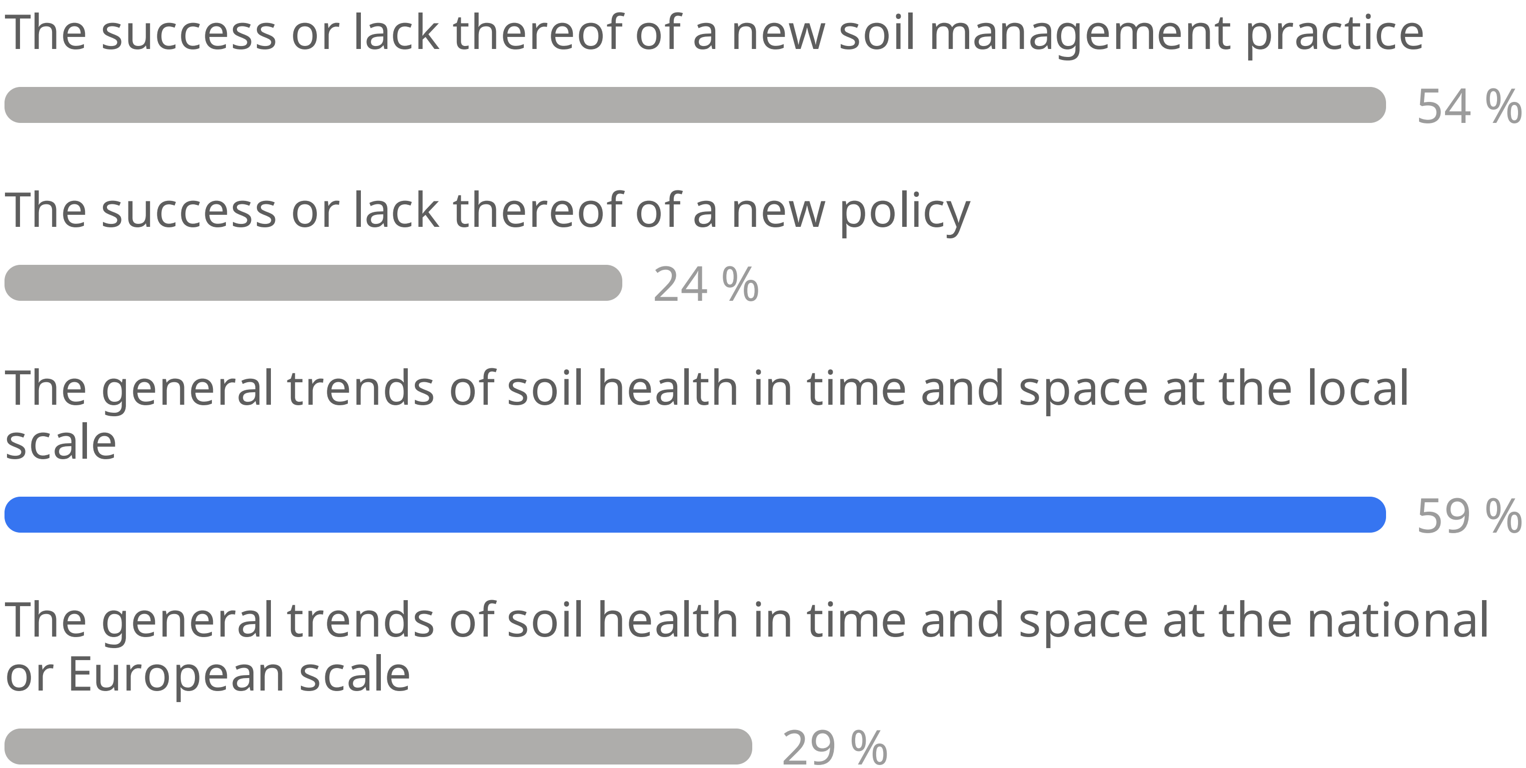
slido

Multiple-choice poll (Multiple answers)

EUROPEAN MISSION SOIL WEEK

What do you need a soil health assessment to inform you about?

101



slido

Multiple-choice poll (Multiple answers)

EUROPEAN MISSION SOIL WEEK

How could benchmarking of soil health help you in the future?

(1/2)

107

To better understand whether the soil management practices I apply are contributing to soil health in my system as expected in my area

58 %

o know which ecosystem services could be delivered by my system, given my context

21 %

To account for how the practices applied in the region/country could support delivery of ecosystem services

28 %

To evaluate the status of soil health in the region/ country

47 %

To evaluate the health of soils across Europe

13 %

Multiple-choice poll (Multiple answers)

EUROPEAN MISSION SOIL WEEK

How could benchmarking of soil health help you in the future?
(2/2)

107

To track where soils are degrading in Europe

13 %

Other

4 %

slido

Wordcloud poll

EUROPEAN MISSION SOIL WEEK

How do you feel about the task ahead?

090

people get the urgency?

i agree with all of them

Loved the event

Very good

Challenging

Inspiring

Vital

Useful

Work

Optimistic

Excited

Encouraged

thrilled

Relief

Exciting

Motivated

Hopeful

Happy

Overloaded

great

Confident

Overwhelmed

Grateful

Inspired

Enthusiastic

Stressed

Join EU

lot to do - but worth it

Optimist

excited and hopeful

yes

Inspired and motivated

Strong

Inspired ans reasured

TOO MUCH TO DO!! 😊

BOS 6 - Blas Cabrera (Building B)

slido

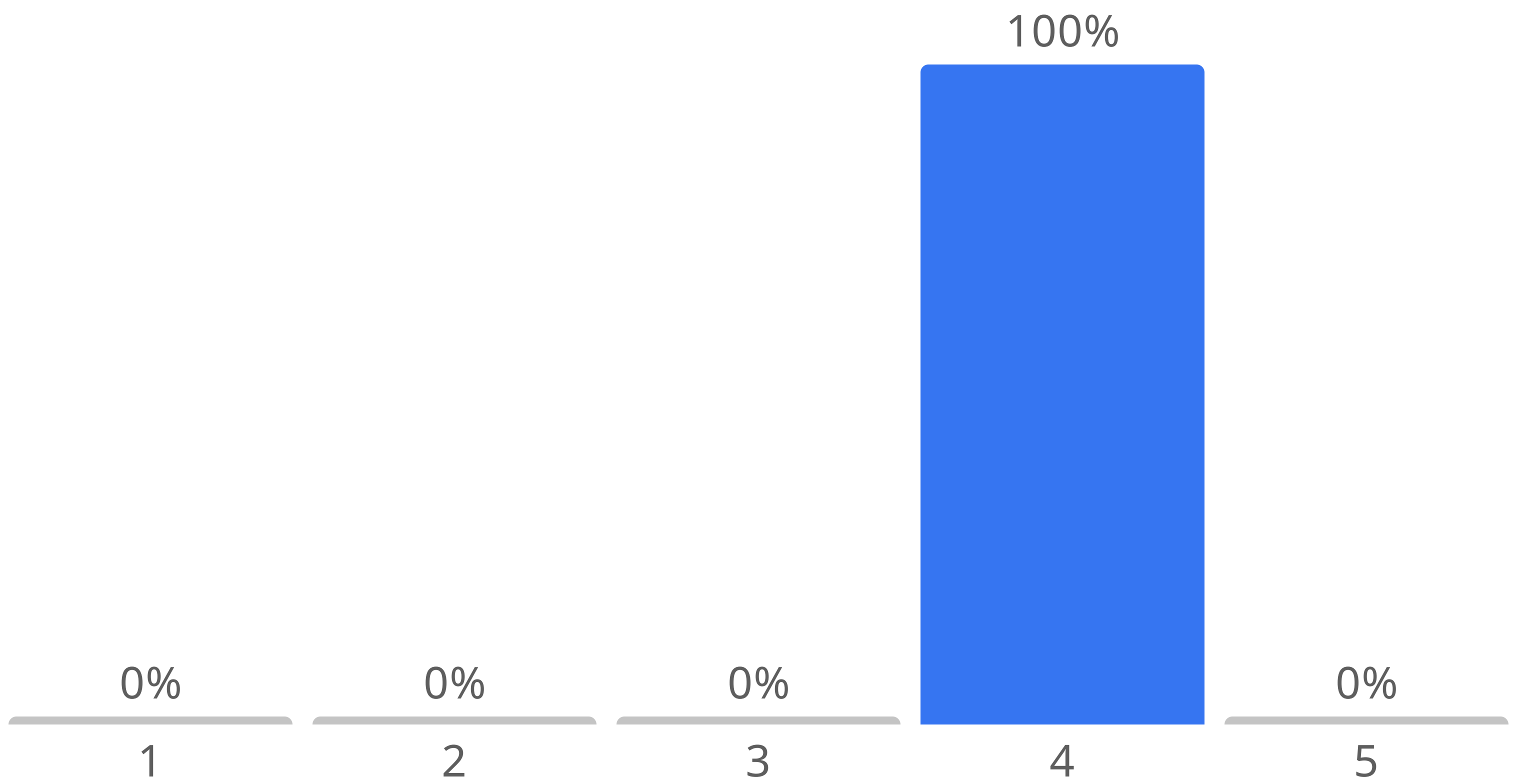
Rating poll

EUROPEAN MISSION SOIL WEEK

From 1 to 5, do you agree with the presented statement about the main soil needs for urban areas

0 0 1

Score: 4.0



slido

EUROPEAN MISSION SOIL WEEK

080

What do you think are the main gaps in promoting the implementation of farming practices for soil health that research still has not addressed?

(1/9)

- Use of hemp or flax as a rotational crop in all farming systems as a phytoremediator
- Effect on overall greenhouse gas emissions
- Economic assesment
- being more accurate in soil biology: building awareness around fungal to bacteria biomass ratio. Biological minimum in compost labels etc
- Demonstration
- Erratic question
- Lack of knowledges and profitability
- Involve farmer
- Better Communication. To select the main parameters easy to measure and easy to understand for farmers to define soil health... And if they are no expensive, the better
- supporting different types of farmers
- explicit data
- Security

EUROPEAN MISSION SOIL WEEK

What do you think are the main gaps in promoting the implementation of farming practices for soil health that research still has not addressed?

(2/9)

0 8 0

- Locally based systemic evalauations based on farmers needs
- Uncertainty
- Better advisory services
- Research on policy incentives (how to implement results-based payment to farmers)
- The costs
- Lack of communication to farmers on which practices can work towards soil health depending on location.
- Farmer resistance Impacts in yields Incentives
- Short term impacts of climate change on the crop production
- the need for scalable, region-specific approaches, and further exploration of long-term impacts and economic viability.
- Use real life examples Involve farmers and advisors on the field in the discussion
- Demonstration of results
- Lack of knowledge

Open text poll

EUROPEAN MISSION SOIL WEEK

What do you think are the main gaps in promoting the implementation of farming practices for soil health that research still has not addressed?

(3/9)

0 8 0

Economic and time costs for new unknown practices

- Hedges in the Landscape
- Practical issues
- Tools to measure the ecological impact of soil health practices
- What is the effect of implementation of such practices on overall agricultural production, and what are the consequences for agricultural land surface area needed to sustain production?
- Appropriate incentives (monetary or equivalent).
- Economic incentives and personal information
- Listen more to land managers
- how to make it profitable
- Cocreate with actors to understand real needs
- Lack of empowerment of advisors (I.e. agronomists)
- Synergies effects
- Growing food for feeding "livestock" under

slido

What do you think are the main gaps in promoting the implementation of farming practices for soil health that research still has not addressed?

(4/9)

0 8 0

- the soil (biota). There is no culture of feeding the soil as live being in the farm
- General information and indicators of implementation
- Interconnectivety of all life that affects soil health
- Costs are the biggest gap. Research should face that
- - context dependency of the success of such practices - gap between academic research and real farming - not taking into account farmers knowledge and know-how in research projects
- Making knowledge accessible
- Long term field trials
- The lack of sharing and valuing all typer of knowledge
- Lack of local information.
- Social acceptance, social factors for farmers
- Knowledge, economic peovlems for farmers
- The transfer of new

EUROPEAN MISSION SOIL WEEK

What do you think are the main gaps in promoting the implementation of farming practices for soil health that research still has not addressed?

(5/9)

0 8 0

techniques to farmers, who will ultimately be the ones who apply them.

- Value-chain collaboration is lacking
- Large scale monitoring does not help with context specific questions
- Ingolf of farmer
- Real demostration experiment data
- Ignoring qualitative research approaches

and listening to people

- Tailor practices to local and practical challenges
- Economical incentives
- To know at local level the agricultural Landscape characterization
- Behavioral understanding of the end users
- Constrains in implementing it
- Plant nutrients needs are no accomplished by organic fertilizers

EUROPEAN MISSION SOIL WEEK

080

What do you think are the main gaps in promoting the implementation of farming practices for soil health that research still has not addressed?

(6/9)

- Se News real drama for restringido and demostración. Experimental plots do not produce real results
- Using more modelling of the systems
- Unknowledge
- Research is based on specific conditions. It is difficult to consider them as general truth everywhere in different landscapes and climates
- Economic studies on the viability of the farms
- Markets pressures
- Risk for farmers to adopt the more convenient practices
- Trust and bravery to try new things behavior science may address it.
- Finding a common language between researchers and farmers
- Engage farmers
- Economic sustainability
- A better practices-outcome approach, where farmers can

EUROPEAN MISSION SOIL WEEK

0 8 0

What do you think are the main gaps in promoting the implementation of farming practices for soil health that research still has not addressed?

(7/9)

understand beforehand the expected impacts of messurements

- Differences in animal farming and plants practices (vegetables, fruits) need to be addressed
- What is a healthy soil
- Practices tailored to local conditions.
- How to monitor
- Capacity to explain soil health
- Chemical pollution & bioavailability/risk
- Invest less in experimentsl research and more in learning from farmers' experience
- Economical incentives for business cases at long run
- Knowledge exchange
- Om farm reserach
- Twchnical assistance and education
- Impact on water
- Productivity an economic issues
- Above and below biodiversity and the

Open text poll

EUROPEAN MISSION SOIL WEEK

080

What do you think are the main gaps in promoting the implementation of farming practices for soil health that research still has not addressed?

(8/9)

link with plant yield and health
- Understanding what works where to provide better guidance to local managers
- More understanding and connection with farmers
- Advisors from official service Witherspoon researxh basis
- Knowledge transfer to farmers
- More socioeconomic research to understand barriers and how to overcome them
- Economic aspects - how much

to pay for good soil
- Knowing what parameters define a healthy soil that contains functional biodiversity
- Demonstration (LH), success stories and output data
- Soil advisory processes
- Summarisation of conventional farming practices that promote soil health
- Sub soil biodiversity
- Behaviour change science
- The economy aspect -

slido

Open text poll

EUROPEAN MISSION SOIL WEEK

0 8 0

What do you think are the main gaps in promoting the implementation of farming practices for soil health that research still has not addressed?

(9/9)

to have fare incomes

- Lack of knowlefge
- Large scale soil monitoring

slido

EUROPEAN MISSION SOIL WEEK

0 8 7

What are in your view the main needs or challenges for efficiently promoting the implementation of sustainable farming practices that contribute to soil health?

(1/10)

- Measure scalability of adopting soil health practices
- Convincing arguments such as e.g. societal appreciation for job of farmers
- Barriers: lack of soil information at local level, cost of soil analysis, microbiologial thresholds to know if we improve the soil quality
- It is necessary give clear and close information to farmers
- Establish clear policies that prioritize sustainable and environmentally friendly agricultural practices, penalizing those that are not.
- Gave enough instruments
- Financial support to farmers to convert to different pactices, more awareness is needed among farmers.
- Means to the practitioners, to text and experiment based on recommendations,

EUROPEAN MISSION SOIL WEEK

What are in your view the main needs or challenges for efficiently promoting the implementation of sustainable farming practices that contribute to soil health?

(2/10)

087

and support in knowledge and practice. Also to improve interconnections

- Peer to peer
- The answer of sustainable farming practices had to rise from the citizens
- Economics challenges: can EU consumers pay a premium for food produced on healthier soil
- understanding about consumer trends. are consumers becoming for plant based or flexitarian, and is this resulting in more demand in legumes and other non-animla protein source
- Share data and results (of both success and failure)
- Cost and more collaboration between involved partners
- Communication between technicians, researchers, farmers and politicians
- Looking for alternativas regarding pesticidas and herbicides

Open text poll

EUROPEAN MISSION SOIL WEEK

What are in your view the main needs or challenges for efficiently promoting the implementation of sustainable farming practices that contribute to soil health?

(3/10)

087

- A common platform to share knowledge outside of scientific community
- Transparent, robust, standard, scalable, and cost-effective methodologies
- Efficient system for knowledge transfer to farmers, more outreach from the researchers
- Farmer collaboration More local site investigation More farm transfers
- Challenge: The farmers needs are not well integrated in Scientific understanding
- Show benefits including economics
- Involve Farmer
- Make economicaly beneficial for farmers
- Innovation and shift in advisory
- Regulation of the market to limit on the one hand harmful practices while on the other rewarding good practices.
- To know what soil healthiest. To

slido

What are in your view the main needs or challenges for efficiently promoting the implementation of sustainable farming practices that contribute to soil health?

(4/10)

087

have a good indicator for soil health and to demonstrate the nexus between soil management and soil health

- The EU needs to stop promoting interests of agribusinesses if the goal is to maintain a diverse rural population
- Greenwashing- are we sure what is delivered need monitoring and science evidence
- A dense network of lighthouses for demonstration of tailored practices
- Peer to peer
- Demonstration of good practices.
- Let the farmers understand both environmental and economical advantages
- Need: Flexible blue print projects that show best practices which can be applied to a respective context
- Demonstrate the economic benefits to

EUROPEAN MISSION SOIL WEEK

What are in your view the main needs or challenges for efficiently promoting the implementation of sustainable farming practices that contribute to soil health?

(5/10)

0 8 7

farmers and provide them with economic support so that they avoid taking risks.

- A multi stakeholder approach where all the parties involved can contribute with their knowledge, experiences and expertise
- Lower production. Food security.
- A good incentive system and language/cultural barriers
- Share and implement data
- Lack of clear policy at national levels

and socioeconomic support for farmers to experiment.

- Providing better information on the selection of practices at a local level and how they intwract
- Again the cost's. If it generates income farmers will do it
- Work all together (and with the same language) : researchers, farmers, policy makers,...
- Effective and affordable soil advisory and testing services made available locally.

EUROPEAN MISSION SOIL WEEK

What are in your view the main needs or challenges for efficiently promoting the implementation of sustainable farming practices that contribute to soil health?

(6/10)

0 8 7

- Policy support - e.g. adapted CAP
- More demostrative collaborative projects... Middle - long term ones
- Advisors and service providers who can design and deliver context relevant solutions
- Not enough demonstration farms (lighthouses) for collaboration between farmers/advisors/researchers
- Promote knowledge transfer farmer networks
- Farmer profitability
- Economic feasibility
- Good information and better systematic research and transfer
- Ensuring farmers will be financially protected to transition to soil health practices (not only organic)
- Assess the innovation at territorial scale and adapt at territorial scale
- Sharing practices and peer to peer collaborations,

EUROPEAN MISSION SOIL WEEK

What are in your view the main needs or challenges for efficiently promoting the implementation of sustainable farming practices that contribute to soil health?

(7/10)

0 8 7

breaking down scientific knowledge to field practitioners

- Regulatory and financial barriers/incentives
- To form the civil society (the consumers)
- localisation, from weather to differences in eating habits etc.
- Taking success stories to the mainstream
- needs: Reduce the farmer risk due to climate change
- Long term studieds
- Spread practical knowledge, coming from other farmers
- Peer pressure and support, farmer to farmer, landowner to landowner
- accessible education, financial incentives
- How much will it cost the farmer? What risk is there for the farmer and will this risk be carried by society or at least shared?
- Policy & education
- Considering the economy at

EUROPEAN MISSION SOIL WEEK

0 8 7

What are in your view the main needs or challenges for efficiently promoting the implementation of sustainable farming practices that contribute to soil health?

(8/10)

farm and regional levels. Finding solutions to overcome economic trade-offs.

- Economic system
- Market change
- Demostrate financial feasibility for gfarmers
- More soil literacy by the administración through its local offices
- Training of advisors
- no framework
- Coordinated programs
- Knowlefge transfer and results demonstration
- Willingness to change
- Give to the farmers more certainty
- Demonstration of good examples and benefits
- Long term studies
- Ensure farmers are active members of the knowledge exchange discussion
- Compensate farmers efforts
- Common language

EUROPEAN MISSION SOIL WEEK

0 8 7

What are in your view the main needs or challenges for efficiently promoting the implementation of sustainable farming practices that contribute to soil health?
(9/10)

- Policy and incentives
- Involve politicians - decision makers
- Funding and carnero engagement
- Reliable advise to the farmers
- The knowledge that farmers have
- Explicit local results
- Information for farmers
- The continual pressure (economic and time) on farmers
- LL & LH to SHOW results
- Local soil testing needs to be available and financially supported
- We need to make science easier to access
- Peer to peer learning and Public advisory services
- Peer-to-peer learning
- Cost and real effects perceived
- Knowledge transfer to practitioners
- Higher costs
- Common language
- Bottom up approach

Open text poll

EUROPEAN MISSION SOIL WEEK

What are in your view the main needs or challenges for efficiently promoting the implementation of sustainable farming practices that contribute to soil health?

(10/10)

087

- Involves farmers

slido

Open text poll

EUROPEAN MISSION SOIL WEEK

What are in your opinion the most efficient way(s) to address those needs/challenges?

(1/10)

086

- Support educational measures and collaborations
- EU Nutritional label: if consumers begin to see what they are really eating, then regenerative farming will become profitable and mainstream almost instantaneously. Nutritional density, human health, soil health
- Soil ambassadors
- Psychological approaches of emotional involvment of farmers. So the are not only preocupied with their survival, But think and feel deeply about their children's future. And financiral support for good practices
- soil health certificazione with clear parameters
- Identify best practices/crop/ local conditions
- More information about soil importance at basic level to increase people interest
- Free soil sampling for farmers to understand their asset and how to act accordingly
- Convince farmers with

slido

EUROPEAN MISSION SOIL WEEK

What are in your opinion the most efficient way(s) to address those needs/challenges?

(2/10)

0 8 6

demonstration experimenrs

- Farmer centric decisions
- Support communication channels and workshops to bring knowledge together at local scales
- Establishing pilot projects that work
- The proposal for the next CAP reform that the Commission should propose in 2025 should be fully aligned with the Mission objectives and provide adequate incentives to farmers to improve soil health
- Stop talking about everything needing to be simple for farmers, instead provide them with the right support for analyses and interpretation
- Applying benefits to farmers that have this type of good practices
- More EIP-AGRI type projects putting the farmers in the centre. Too much research is for the benefit of academics rather than meaningful outcomes.
- Capacity building for all AKIS actors
- Researchers: Simplifying the

EUROPEAN MISSION SOIL WEEK

What are in your opinion the most efficient way(s) to address those needs/challenges?

(3/10)

086

paper work and increase project findings. Farmers: increasing compensations if they use nature based solutions

- Founding a local soil advisory + testing + infocentre (or upgrading existing service) to support farmers. Also regional coordination to find mutual benefits.
- Research involving farmers from start Labelling of inputs Information for consumers on true costs of negative externalities (soil pollution)
- Peer to peer knowledge shared in farmers associations
- Collective support schemes to reach landscape-level changes.
- De-risking for farmers willing to change practices
- Generating funds and promoting real transdisciplinary research and efficient interaction among bottom up and top down approaches
- With the development of local programms involving skaterholders and local authorities

EUROPEAN MISSION SOIL WEEK

What are in your opinion the most efficient way(s) to address those needs/challenges?

(4/10)

0 8 6

- Involve Farmers into research programs by funding activities
- Soil health passports
- Collect as many data ad possible and let them be available by farmers and technical assistance
- It’s in transdisziplinary und multiprofessionell work together an policy framework
- Crossdisciplinarity and locally based research
- Common databases, financial resources, long-term experiments, farmers financial support for the implementation of alternative practices and soul analysis
- Strenghten advisory services & provide funding (infraestructura needed, training, compensation)
- Communication and increase literacy
- Incentives that promote best practices in each area
- Low costs of incomes ro facilitate the change
- Lower cost of the soil analysis, soil advisory team and data base to compare the results

Open text poll

EUROPEAN MISSION SOIL WEEK

What are in your opinion the most efficient way(s) to address those needs/challenges?

(5/10)

086

- Close contact with farmers so that they find meaning in the new practices that are proposed and can apply them with conviction in understanding how the ecosystem works.mers
- Demonstration or learning farms; peer to peer knowledge transfer; attracting young farmers to join research projects.
- Support transition and involve farmers in a co creation appproach
- Extension agents, free advise. Mass media, radio slots addressing thèse practices
- Less academic, more practical approaches
- More collaborative/ co-creation research projects (at national/regional scale as well as at EU)
- Lighthouses with local farmers strongly supported by the system
- Education sharing experiences among farmers with different practices
- Consult farmers/land managers about their needs and opinions

slido

EUROPEAN MISSION SOIL WEEK

What are in your opinion the most efficient way(s) to address those needs/challenges?

(6/10)

0 8 6

when designing incentive systems and management strategies

- Promoting advisory services
- Rethink the system of publications in science as a means to prove you do good project work with farmers. Both are important.
- To create expertise group (with all the actors) to evaluate the possible solution from the agriculturql, environmental and economical point of view
- Knowledge support for farmers
- Redirect investments towards

supporting farmers with extension services (not the CAP) and knowledge exchange of proven effecrive practices

- Collaborating with land managers to understand the barriers to adoption
- Collaboration between different actors More funds
- Funded projects should collaborate more efficiently
- Demonstrations at farm level with pratical information
- Create market incentives for farmers and

EUROPEAN MISSION SOIL WEEK

0 8 6

What are in your opinion the most efficient way(s) to address those needs/challenges?

(7/10)

landowners to invest in their soil, support their contribution to ecosystems services, open to private markets

- Local test and colaborative process
- Good financial system. At the begginig support is needed: money and clear information how
- Support peer to peer learning
- Provide context specific knowledge on soil health at local levels
- CAP supporr
- Direct contact and

engagement of the different stakeholders and make clear action plans, with short and long term vision

- School courses and soil literacy
- Involve financial investors
- Make interaction of science, farmars and advisory closer
- Multitasking approach
- Develop efficient AKIS for supporting and monitoring, an for knowledge co-creation
- Eat locally
- Farmers consultation of research activities and programs

What are in your opinion the most efficient way(s) to address those needs/challenges?
(8/10)

0 8 6

- Sharing experiences and training
- Make soil health practices more profitable for farmers
- More involvement of farmers in such decision processes
- The research projects need a long term commitment to farmers' needs
- Organizing supply chains to include regenerative products into the market
- To develop approaches based on local knowledge and engage with farmers.
- Incentives, including tax incentives and subsidiea
- Soil health monitoring law based on the right paramaters (e.g. functional biodiversity)
- Design (concreate) roadmap for farming based on national rules
- FULLY ALIGN THE CAP WITH SOIL HEALTH, CLIMATE, AND BIODIVERSITY!
- Protecting farmers from the economic risks of their commitment to better agricultural practices.
- More collaborative process
- A well-developed

EUROPEAN MISSION SOIL WEEK

What are in your opinion the most efficient way(s) to address those needs/challenges?
(9/10)

0 8 6

advisory system.

- LIs
- Social media/YouTube of case studies.
- Landowner collectives, supported by soil and environmental advisors, based on scientific research
- Politicals should know better farmers and farmer conditions
- Ok farm demonstration initiatives
- With capacity building
- Demonstration and stakeholder engagement
- Advisors, CAP
- Strong farmers advisory services
- Better finanncial support to researches and key farmers and improve extension services
- Public and well trained extension services
- Relate soil health to practices and advice on how practices can help
- In a participatory way involving all the actors
- Events, get in touch with farmer and listen to them
- Support for peer to peer learning.

Open text poll

EUROPEAN MISSION SOIL WEEK

0 8 6

What are in your opinion the most efficient way(s) to address those needs/challenges?
(10/10)

- Farmers involvement
- LL approach
- Social media contribution
- Training of trainers approach
- collaborative platforms, market access, monitoring and evaluation, capacity building, and community engagement.
- Extending research grants
- COLLABORATION ON ALL SCALES
- Investing in research and eduction.
- Public investments on farmers
- Implement a data sharing culture
- Policymaking
- Write more projects. Need more money
- Design appropriate visual graphics for all audiences
- Provide local testing services
- Peer to peer learning

slido

What do you think the Mission Soil can / should do to efficiently promote farming practices for soil health?

(1/9)

085

- A lot od advertisemet for general public
- Networking LLs
- Bringing together and documenting the knowledge and data on best practices already created in living labs / lighthouses to be shared for everyone interested.
- Improving knowledge about soil biodiversity and its effect in crop growth and survival. Increasing global knwledege and practice
- Involve more farmers in their work
- More mission projects explorinh the link between the CAP and farm practices
- Promote practices already EU law which are known to deliver on soil health. Promote system solutions which give livelihood to rural farmers.
- More Funding of practioners/farmers...
- Spread the results with clarity for all stateholders
- Special funding system

EUROPEAN MISSION SOIL WEEK

What do you think the Mission Soil can / should do to efficiently promote farming practices for soil health?

(2/9)

085

for capacity building and local networking supporting peer learning

- Field Labs (practice focused) to complement Living Labs
- consider farmers as partners AND NOT JUST AS DATA PROVIDERS
- Traslate soil research to policy and end users
- Improve soil literacy. Demonstrate the local effects of specificpractices
- A fixed stakeholder engagement approach for all projects, to ensure stakeholders are seen, heard and integrated
- Spreading efficiently the practical knowledge obtained in farms/living-labs YouTube videos with relevant and accurate examples
- Put some target (different for any district) that all the EU country has to reach
- Create a network of advisors.
- Work at local level, simplify the language use

EUROPEAN MISSION SOIL WEEK

What do you think the Mission Soil can / should do to efficiently promote farming practices for soil health?

(3/9)

085

to farmers, enhance soil indicators and mapping

- Support a big nubmer of farmers to get involved to the project because these farmers will be the magnet for others (Peer to Peer)
- Focus also on Urban agriculture
- Increase soil literacy among everybody
- Promote fair food prices within the EU, with fair prices for farmers that honestly reward their efforts towards better soil quality and a better environment
- Policies to incentivize farmers
- Knowledge exchange structures based on bottom up approach (farmers' knowledge to advisors/ researchers/ policymakers
- Securing local & regional stakeholders engagement with soil health promotion measures
- Via diverse communication channels to increase the awareness. Seeing is believing.
- Support research projects
- Create national networks to promote

EUROPEAN MISSION SOIL WEEK

What do you think the Mission Soil can / should do to efficiently promote farming practices for soil health?

(4/9)

085

multi actor knowledge exchange

- Connecting farmers, researchers and policy makers. More collaborative projects and meetings.
- Stakeholder involvrment in research phase
- - Unification of European projects and knowledge - create ecological standards for regenerative agriculture
- Find what people are doing. Farmers are moving faster and BETTER than policies.
- Long term funding strategies
- Talk to people outside the bubble
- Farmers erasmus
- Promote better interaction among different spheres of knowledge and practice, giving space and building detected synergies
- Funding knowledge exchange among farmers, setting up more living labs, demonstrations.
- support good practices
- More information and credibility at local level

EUROPEAN MISSION SOIL WEEK

What do you think the Mission Soil can / should do to efficiently promote farming practices for soil health?

(5/9)

0 8 5

- Create a consistent soils database which can be user friendly for all stakeholder groups. Have associated metadata language to go alongside.
- Focus on shifting the incentives for field practitioners, finding new business cases for healthy soils
- Identify positive evidence-based practices and describe how to apply them in practice.
- Make the projects more accessible to non-research or applied research organisations
- Improve the benefits for farmers that apply this practices
- Promote follow up projects that build on the results and learnings of previous ones.
- Communicate the results, incentivise the change, support the farmers economically
- Workshops
- Stablish stable living labs and guidance
- Tools for self assessment of soil Health
- Improve interactions

EUROPEAN MISSION SOIL WEEK

What do you think the Mission Soil can / should do to efficiently promote farming practices for soil health?

(6/9)

0 8 5

- Training advisors on the results
- LL
- Funds Promote collaboration between different actors
- Support training for advisors and technician based on projects results
- to give the farmers a certification living clear parameters that take in account different kind of soils
- Citizen and Farmers' Engagement
- Projects commitment to the farmer needs
- Farmers in the Mission Board
- Support more projects on LL approach
- Capacity, spread information
- Citizens and farmers awareness.
- Increase connection between different stakeholders
- More money for farmersto suport innovation
- Soil literacy
- Do not disperse or duplicate research efforts
- Improve comunication at local level
- Closer ties with farmers

What do you think the Mission Soil can / should do to efficiently promote farming practices for soil health?

0 8 5

(7/9)

- Suport more LLs
- Farmers at the centre
- 1. have an understanding of the best farming practices, evolving farming practises.
- Higher control of project considering the expectations of the mission
- Funde landowners to experiment
- Concentrate on living labs as key funding stream
- Creating pilot projects and getting close farmes to researchers.
- Increase the focus on long-term research and integrate climate challenges
- Finanziate longer projects, 4 years are too little to implement and test practices
- Pay farmers to experiment with new crops.
- Suggest ideas and actions to farmers and goverrments
- Dissemination of the horizon europe proyect results
- providing training programs, forming partnerships,

EUROPEAN MISSION SOIL WEEK

What do you think the Mission Soil can / should do to efficiently promote farming practices for soil health?

(8/9)

0 8 5

offering financial support, integrating technology,...

- Funding farming practices, farmers and new incomers
- LL as testing, knowledge and pracrice monitoring centres
- Spred information more widely.
- Create a soil data base and advisory service
- form a framework, set examples
- Dissemination, activities that target farmers, livings labs
- Facilitate collaboration with stakeholders
- Knowing the real situation of farmers
- More visibility at local, regional and National level
- Support projects on the socioeconomic aspects of farming practices for soil health
- Make clear messages to practitioners
- Active data sharing
- Quarterly workshops for all recognised stakeholders. Open this for all parties, not just scientists and academics.

EUROPEAN MISSION SOIL WEEK

What do you think the Mission Soil can / should do to efficiently promote farming practices for soil health?

(9/9)

085

- Reduce the size of projects and funds more initiatives
- Develop good soil health indicators
- Improve research at local levels, reduce emphasis on European scale
- Living labs and tons of outreach
- Lobby the CAP
- Capacity building
- Scale up solutions

Open text poll

EUROPEAN MISSION SOIL WEEK

What do you think the Mission can/should do to advance in this particular area?

(1/3)

0 3 8

- Include industry with policy makers
- Cascade funding for stakeholders engagement
- More experiences of Living Labs in Latin America
- Support for farmer led initiatives
- More sharing of best practice examples
- Promoting network & exchange expetiences
- Diversity of membership
- More support to potential project leader (although Natioons and soill should help)
- Fund 100 percent the farmers
- Lobby universities to provide extension services like they have in the USA. Dedicated to Ag.
- Give room for failing forward and dare innovate - the application/ reporting needs to allow for this
- More diversity. New institutes should have more opportunities to participate.
- More support to technicals and farmers
- A clear view on the long term. How do LL stay (financially) sustainable?

EUROPEAN MISSION SOIL WEEK

What do you think the Mission can/should do to advance in this particular area?

(2/3)

0 3 8

- Prividing support
- Better proposant guidelines
- More budget for LL
- Networking events
- Higher share for cascade funding
- Better co creation and co implementation with actors. Farmers aren't just end-users and can be players in the sustainability of living labs
- Conect with farmers
- Lab
- Engagement
- Bigger financial support
- More budget
- Get other funders on board
- Pathways for synergies and connections between all actors
- Be more clear in the real cases
- Share examples
- Mire budget depending on how many partners
- Continuation of support
- Favouring long term financial support
- Foment networking events
- Operative contacts
- More budget for living labs, let’s get it on

What do you think the Mission can/should do to advance in this particular area?
(3/3)

038

- Knowledge sharing
- Lump sum finance model
- Simplified procedures
- Take the work with on the ground stakeholders and see what they each need. Money, resources, education, all?
- Develop and support participatory processes
- Examples on how to design structure of a living lab
- More LL with support
- Funding of follow up projects
- More real life (good news!) Stories 👍
- Introduce subsidiers for farmers participating in living labs
- More budget

BOS 7 - ICA Institute (Building C)

Which synergies are most relevant for including in MRV systems for carbon farming?

053

Production biodiversity
Measurement methods
Ecosystem services
Soil quality
Efficiency
Climate adaptation
Climate change
Money
Food security
Soil health
Yield
SOM
Water flows/contaminants
Productivity
Carbon stock
Som quqlity
Biodiversity
Sustainable farming
Soil erosion
Crop system
Management
Water quality
Water retentiion
Water retention
Economics
aoil biodiversity
Business models
Farmers
ecosytem services
Resilience
Water
Life cycle assessment
Social
Soil structure
SOM structure
Economic viability
Cost effective methods

Wordcloud poll

EUROPEAN MISSION SOIL WEEK

Can you think of any practices that are "no regret" options which minimise trade-offs between carbon and other GHG and nutrient losses?

0 5 1

Value adding to residues on farm level
Holistic grazing
Cove convert to grassland
Plant residues
Climate smart agriculture
River restoration
Water retention structure
Crop rotation
Agroforestry
No till
Forest planting
Reduced tillage
Cover crops
Waste management
Intercropping
Organic farming
Legumes
Permanent grasslands
Agroforesty
Rotation
Biochar
No tillage
Regenerative farming
Permaculture
Hedgerow planting
Valorizing agroresidues
Reduced till/cover crops
Conservation agriculture
Enhanced biochar

Multiple-choice poll

EUROPEAN MISSION SOIL WEEK

061

At the current stage of knowledge about synergies and trade-offs associated with carbon sequestration in soils, what kind of approach would you recommend for carbon-farming schemes:

Result-based schemes (paying for outcomes achieved)

41 %

Practice-based (paying for measures applied)

52 %

None of the above/don't know

7 %

slido

Wordcloud poll

EUROPEAN MISSION SOIL WEEK

Apart from those addressed in the presentations, are the any other potential synergies that deserve greater attention?

047

Plant-animal integrated on farm
Communities awareness
Agrotourism
Socioeconomics
Social benefits
ecosystem service benefits
Farmer profitability
Rural abandonment
Water quality
Rural development
biodiversity conservation
Water available
Landscape
Water use efficiency
Water availability
Culture
Economics
Safety
Life on the land
Ageing
Land ternure
Water infiltration
Social
Resilience
Substrate reuse
Yield
Good image
Water retention
Manure
Cascading effects
Soil chemical composition
Poverty levels
Farmers' worklife life in the future
Data harmonization

Apart from those addressed in the presentations, are the any other potential trade-offs that deserve greater attention?

041

Limits to SOM levels regionally differ
Local circumstances
Land management
Data modelling
Greenwashing
Erosion
Costs
Monitoring
Contamination
Poverty
EU
Desertification
Production
Water competition
Social barriers
pH
biodiversity conservation
Yield
Scalability
Decrease in yields
SOM loss due to droughts
regions
Ecosystem services
Contaminants
Pathogens
covering
Yeild
Scaleability
Land abandonment
geographical
Pollutants
Water availablility
Land use
Data harmonization
Farmer workload
Data
Contamination by organic inputs
Production Costs
Long term experiments
Costbenefit
Environmental protection

Open text poll

EUROPEAN MISSION SOIL WEEK

What would be the most useful contribution(s) from Mission Soil towards creating synergistic carbon-farming schemes in the EU?

(1/4)

045

- knowledge sharing like this
- Lobying
- Urban agriculture?
- Funding for collecting field data
- Fair indicators
- Achieveable targets
- Research
- Making research work together
- living labs & light houses
- Awareness raising
- Regional baselines
- Good practices
- MRV
- Cheap MRV
- Best practices
- MRV
- involving citizens
- Measuring impact
- Long term measurements on peat soils in underrepresented areas
- Raising awareness of decision makers
- Funding
- Finance advice
- Living labs

slido

What would be the most useful contribution(s) from Mission Soil towards creating synergistic carbon-farming schemes in the EU?

(2/4)

045

- Diversity-based solutions, avoiding monocultures
- Emphasise management that reduces CH4 and N2O emissions
- Soil health economic value
- Follow up projects
- Long term measurements
- Financial aid for regions with more challenges to enhance SOC
- Funding
- New opportunities for rural development
- Comparing different MRV systems results on the same area
- Business models
- Providing a platform for collaboration among different groups of stakeholders
- Results-Impacts
- Showing what works, science-(policy)-practical interaction
- Funding
- Clear knowledge transfer to decision makers
- Funding for n2o emissions
- Contextualizing
- Harmonized data
- Success stories

EUROPEAN MISSION SOIL WEEK

What would be the most useful contribution(s) from Mission Soil towards creating synergistic carbon-farming schemes in the EU?

(3/4)

045

- Long term measures
- Open datasets
- find agreement among scientists on thresholds
- Regulations after research knowledge
- Funding
- Knowledge dissemination
- Developing MRV systems
- Setting best practices
- Harmonize national policies
- Training and capacity building
- Bottom up approach
- Better climate resilience
- Support monitoring of multiple indices
- Long-term measurements
- Develop communication material that speak to farmers
- Living Labs as demos
- Good examples
- Harmonized method to quantify carbon stocks
- Best practices
- Advice to go beyond carbon farming
- Common framework

EUROPEAN MISSION SOIL WEEK

What would be the most useful contribution(s) from Mission Soil towards creating synergistic carbon-farming schemes in the EU?

(4/4)

0 4 5

- Involving farmers and municipalities
- Assessing best agri practices
- Better involvement of farmers and policymakers
- Living labs
- Research

Open text poll

EUROPEAN MISSION SOIL WEEK

What are the main gaps for efficiently promoting the implementation of sustainable farming practices that contribute to soil biodiversity?

(1/3)

043

- Lack of comminication and understanding among stakeholders. Special social skills to work with farmers. Economic evaluations
- Short term projects vs. Long term methodology to check properly biodiversity
- Knowledge of the funtionality of the biodiversity
- Value chains
- Effective Farm advisory service
- Co-creation
- Logal or regional agreement on what should be protected and how.
- Indicators threshold, yield and productivity
- Most farmers struggle to survive. No time for innovation.
- The assessment is too expensive
- AWARENESS
- Coaching
- Farmers are neither understood nor participants in the decision process
- Lack of understanding by the public of

slido

EUROPEAN MISSION SOIL WEEK

What are the main gaps for efficiently promoting the implementation of sustainable farming practices that contribute to soil biodiversity?

(2/3)

0 4 3

soil biodiversity as a driver for agriculture

- Societal appreciation of land stewardship
- Awareness and money
- Information and definition of biodiversity value
- Lack of supply chains to bring those regenerative products to society
- We need comprehensive application of agroecology principles
- Communication and outreach

to relevant stakeholders

- Lack of knowledge
- Links to ecosystem services and functions
- The fertility
- Collaboration academia-users
- Lack of large-scale examples
- Ecosystem degeneration is profitable. Regeneration is a cost. The problem is politicoeconomical
- Confusing concepts... Quality, conservation, precision, health, eco, bio....
- Lack of efficient

Open text poll

EUROPEAN MISSION SOIL WEEK

What are the main gaps for efficiently promoting the implementation of sustainable farming practices that contribute to soil biodiversity?

(3/3)

0 4 3

communication with farmers

- Extensive surveying
- Listen to farmers
- Funding for long term experiments
- Education at school and highschools: they are future generations
- Definition of biodiversity
- Involving farmers
- Information
- The definición of soil Biodiversity
- Funding
- Methodology
- Definition of biodiversity
- Linking biodiversity to functional thresholds
- Clear functional links
- Short term
- Good indicators and reference values

slido

EUROPEAN MISSION SOIL WEEK

How can the Mission Soil meet those requirements?

(1/3)

039

- Stop financing industrial agriculture and promote regenerative farming in legislation
- Creat intrnational open access databas for all thses projects
- A CSA call to cluster the EU projects and put together the results
- Literacy
- Guide the measures set in CAP, Calculate the costs induced by change of practices to highlight the means needed to reach objectives
- providing resulta but somebody should study them
- Soil biodiversity atlas is good background to start with. Then funding to studies reflecting temporal and spatial changes and analysing the reasons for those.
- Create a steering committee with farmers in parity with other players.
- Uniform methodology
- Incentives for farmers
- Promoting mainstream of soil biodiversity monitoring
- Open project calls that are more

EUROPEAN MISSION SOIL WEEK

How can the Mission Soil meet those requirements?

(2/3)

0 3 9

open and accessible to farmers

- Good examples
- Enhancing cooperation and with longterm projects
- BEST practices investment
- Provide more visibility for soil biodiversity
- Clear definition of Living Labs
- Implemented a protocol
- Unify monitoring systems
- Invest in Research
- Defining a clear conceptual framework
- Sharing good examples and results
- Found the creation of cheap biodiversity assessment tool kits
- Link Mission soil Resultat to CAP revisions
- Living labs should be the ones that will help
- Implement demonstration projects
- Long term fundings, datasets available for everybody
- Long term funding
- Living labs
- Make better bridges with farmer associations and food/agri companies

EUROPEAN MISSION SOIL WEEK

How can the Mission Soil meet those requirements?
(3/3)

039

- Long term sustainable lighthouses
- Long-term in situ experimental fields
- Align CAP with Mission Soil
- We need to move away from pure CAPITALISM
- Put all actors together
- Real living labs
- With living labs
- More fundings. Less burocracy
- Funding

Multiple-choice poll

EUROPEAN MISSION SOIL WEEK

0 5 4

Who is present in the audience? (Choose one description that fits you best.)
(1/2)

Farm/Soil Advisor (agricultural)
6 %

Soil Advisor (non-agricultural)
0 %

Researcher
43 %

Farmer (agricultural land manager)
13 %

Land manager (non-agricultural)
0 %

slido

EUROPEAN MISSION SOIL WEEK

Who is present in the audience? (Choose one description that fits you best.)

(2/2)

0 5 4

Policy-maker

17 %

Other

22 %

Multiple-choice poll

EUROPEAN MISSION SOIL WEEK

What was your main interest in joining this session? (Choose one)

0 5 7

Knowledge transfer to farm advisors

47 %

Knowledge transfer in general

33 %

Advisory services in general

11 %

Just interested

9 %

slido

EUROPEAN MISSION SOIL WEEK

How do you think the proposed Soil Monitoring Directive will affect farm advisors and their knowledge needs? What additional/different knowledge objects would be required?

(1/5)

0 3 7

- Soil biology awereness and minimum indicators (fungal to bacteria ratio, the rol of predators, aerobic and anaerobic conditions in soil for microorganisms, their role for compaction, structure, nutrient circulation and density, weeds control...). Microbes are more than "microbes"
- Adopting a robust challenge criteria to assess appropriate indicators.
- Labas
- Training programs and resources to design implement monitoring demands
- Nutrient density
- Easily accessible and understandable soil information
- They will need update information about soil indicators, plant nutrition needs, new organic materials response in soils
- Knowledge about indicators,

EUROPEAN MISSION SOIL WEEK

How do you think the proposed Soil Monitoring Directive will affect farm advisors and their knowledge needs? What additional/different knowledge objects would be required?

(2/5)

0 3 7

soil management techniques and economic impact

- Indicators for soil health
- Deeper knowledge on bettering Soil quality management techniques and technology.
- Indicators/thresholds of soil health
- How to reach necessary soil health targeted goals))
- Micronutrient and Micronutrients interaction and nutrient density
- Understanding legislation

restrictions.

- Improving and facilitating their actions Harminisation of informatio
- The directive needs to allow time for advisors to be update with the new needs and flexibility to adapt to local needs
- Clear information about the monitoring and analysis procedures
- Advisors will need to know what soil indicators need

EUROPEAN MISSION SOIL WEEK

How do you think the proposed Soil Monitoring Directive will affect farm advisors and their knowledge needs? What additional/different knowledge objects would be required?

(3/5)

037

to be monitored and how un their particular country.

- This Directive should be developed at National level, then the National legislation and nation based requirements will be definitive
- The once about economic und selling Products
- Interpretation of Soil parameters
- Integrated local soil management strategies
- Understand health soil indicators
- Soil analysis benchmark
- Possible scalability of projects and common monitoring assessment practices proved successful accross the EU, which practices could enhance soil health while providing a business case additional with minimal admin. burden
- No idea. Clarify what soil quality/health is and try to promote between farmers
- Soil data harmonization

EUROPEAN MISSION SOIL WEEK

How do you think the proposed Soil Monitoring Directive will affect farm advisors and their knowledge needs? What additional/different knowledge objects would be required?

(4/5)

0 3 7

- questions About whether their soil is healthy
- Clear definitions of terms e.g. soil health.
- More holistic ecological knowledge
- Soil data Standardization of methodologies
- Soil maps missing in many European regions
- Will need more holistic knowledge
- A unique and widely applied Soil health framework
- More social input
- Before thinking about the effect we need to dissimenate the directive propperly!
- How to assess soil health at a farm level?
- Knowledge about Soil indicators which refer to many soil different characteristics
- Clear descriptions of soil districts
- Soil maps and specific indications for contaminated soils
- Need knowledge on soil health

EUROPEAN MISSION SOIL WEEK

How do you think the proposed Soil Monitoring Directive will affect farm advisors and their knowledge needs? What additional/different knowledge objects would be required?

(5/5)

0 3 7

- The knowledge objects would need to be practice orientated. Otherwise it's time consuming and inefficient if each advisor has to analyse a report to get the necessary information.
- State of functional biodiversity
- Live stream is available only for plenary sessions.
- Better access to soil and farm data

What type of knowledge exchange approach do you use the most? (Please rank the approaches from most used to least used.)

042

1. Peer-to-peer approach. — 2.93
2. Multi-actor approach. — 2.79
3. Top-down approach. — 2.19
4. Bottom-up approach. — 2.10

Open text poll

EUROPEAN MISSION SOIL WEEK

What is missing for knowledge transfer to advisors, and how could advisors and/or the Climate Smart Advisors project contribute to those knowledge gaps?

(1/3)

0 2 0

- More comunication among stakeholders
- Researchers need to be recognised for Knowledge transfer to Soil advisiros
- Impact assessment
- Trust. Specific local conditions lead to mistrust of general rules
- Better understanding of the needs of each others
- Consistent, simplified, understandable language for all user groups.
- Test solutions in long term trials - can it be compensated by metanalysis and modelling?
- A gap would be impact assessments and inclusion of stakeholders responsible for the implementation
- How to tackle the human resources availability, i.e. training enough people to scale up
- Real innovations there is sometimes too much talking and no innovation

slido

EUROPEAN MISSION SOIL WEEK

What is missing for knowledge transfer to advisors, and how could advisors and/or the Climate Smart Advisors project contribute to those knowledge gaps?

(2/3)

0 2 0

- Dedicated training courses missing Place based knowledge gaps Add local knowledge to a database
- Prioritizing agroecological knowledge and promoting agroecological practices
- Stable and permanent focal points of applied knowkedge and extension programms
- Stablished ways for interaction and synergies between different stakeholders
- Farmers should be Center and advisers
- Moderated online discussion forum
- Capacity building and training services
- Advisors need to be part of the co creation and Co implementation of projects
- Improved skills on communication
- Impact indicators
- Tacit knowledge from crucial

EUROPEAN MISSION SOIL WEEK

What is missing for knowledge transfer to advisors, and how could advisors and/or the Climate Smart Advisors project contribute to those knowledge gaps?

(3/3)

0 2 0

stakeholder user groups.

- Paths for better communication and dissemination of results

Open text poll

EUROPEAN MISSION SOIL WEEK

What do you think the Mission can/should do to advance in this area? (Knowledge transfer to farm advisors)

(1/4)

0 3 4

- Question the general approach/structure/ of the projects currently funded for the impact they have in practice
- More on vegan and horticultural foods
- Farmers as Advisers Farmers to Farmers direkt
- Including this topic as wp of project
- Find more farm advisors to be trained and use artificial intelligence applications to complement live personal farm advise
- Involve agricultural solutions vendors
- Coordinate the synthesis of knowledge emerging from the eu projects on soil
- Training modules from R&I results
- Better use of thr MAA Advisors and advisor organisations aren't just stakeholders here, they can play an important role

slido

Open text poll

EUROPEAN MISSION SOIL WEEK

What do you think the Mission can/should do to advance in this area? (Knowledge transfer to farm advisors)

(2/4)

034

in the implementation of these projects and should be involved as partners to better improve the communication and exploitation.

- Sharing BP
- Employ farmers
- Link tech advice with real economic value
- Trainning the advisors in the use of these technologies and how find all the available information
- Favour the Involvement of advisors in projects to listen to their experience and knowledge requests
- Use of non scientific language
- I think should have a master or bachelor degree orientated to farm advisory.
- It could provide a huge website as a repository of knowledge arranged in different languages and topics
- Host events like these to communicate the most important results of each project. Centralising information

slido

Open text poll

EUROPEAN MISSION SOIL WEEK

What do you think the Mission can/should do to advance in this area? (Knowledge transfer to farm advisors)

(3/4)

0 3 4

- Support region-specific collection and interpretation of data
- Translation of knowledge to practice
- Acknowledgments of good practice
- Coordinate knowledge platforms to avoid each project develops its own. Rather feed e.g eu farmbook
- Taking the advisory services in the project consortiums.
- Centralize and Channel información
- Collect and showcase more on field examples. Both good and bad examples.
- Maintain funding to project (local) networks and for continued knowledge transfer after project ends Fund particularly education of advisors and peer groups
- Interact more with organisations with knowledge exchange expertise and appropriate network
- Connect international
- Create visible job positions that

slido

What do you think the Mission can/should do to advance in this area? (Knowledge transfer to farm advisors)

(4/4)

034

allow multidisciplinary knowledge transfer

- Merge all the knowledge platforms/hubs from projects
- Organize available information
- Listen to farmers.
- Funding
- Establishing organised pathways for communication flows
- Specific topics on soil advisors, maybe divided by sectors.
- Quarterly workshops to discuss routemap of progress.
- Organize the projects

results and disseminate

- Gathering información though repositories, maybe including in farmfbook
- Train and support agroecology advisors

EUROPEAN MISSION SOIL WEEK

What is your preferred way to access information? Where to find it? What form that information should take?
(1/3)

038

- 1By internet, on field, call up researchers, mob. Apps 2There are too much platform and websites. We have to merge them. We don't have time to access and check all of them. 3Video, short comunication, mob, apps...
- Videos
- Match making tools for specific issues
- Interactive apps (and user friendly!!)
- Mobile APP
- Easy and interactive tools
- Through a song
- Online. Organisations I trust. Clear combination of text, images and diagrams.
- Website
- On line, Public repository, datasets and reports
- As a researcher the WOS, researchgate, regional bulletins
- Online and cloud
- On line . Tecnical publications In soecifics website
- Currently, internet Accurate

EUROPEAN MISSION SOIL WEEK

What is your preferred way to access information? Where to find it? What form that information should take?
(2/3)

038

websites Documents, videos

- Online and printable.
- Online, friendly-user, chatbot is a great idea!
- Interactive workshops
- Advisors
- On line
- Good summaries of data and information (with supporting documents for additional study)
- Website, form of articles, testimonies, infographics easy to use, tables and use books
- Web Semnars
- Email subscription to farmbook did not work for me
- Online
- Explain concepts with visual aids
- Online From an official website Information with references or some previous revision
- Short concise easy to find online policy briefs
- Maps with region-specific info
- Online videos and face-to-face transfer
- Hands on workshops
- Interactive, show-casing

Open text poll

EUROPEAN MISSION SOIL WEEK

What is your preferred way to access information? Where to find it? What form that information should take?

(3/3)

038

- IA chat bot
- Online as a first approach but then hands-on and peer-to-peer are to be preferred
- Podcast
- Internet
- Geospatialized information
- Online Easily accesible from EU repositories Infographics and easy to read abstracts
- Podcasts
- Written
- Workshops
- Web
- Websites
- Online tools
- Books
- Online
- Centralised
- YouTube
- Technical magazines (paper or online)
- online, videos
- Interactive
- Online

slido

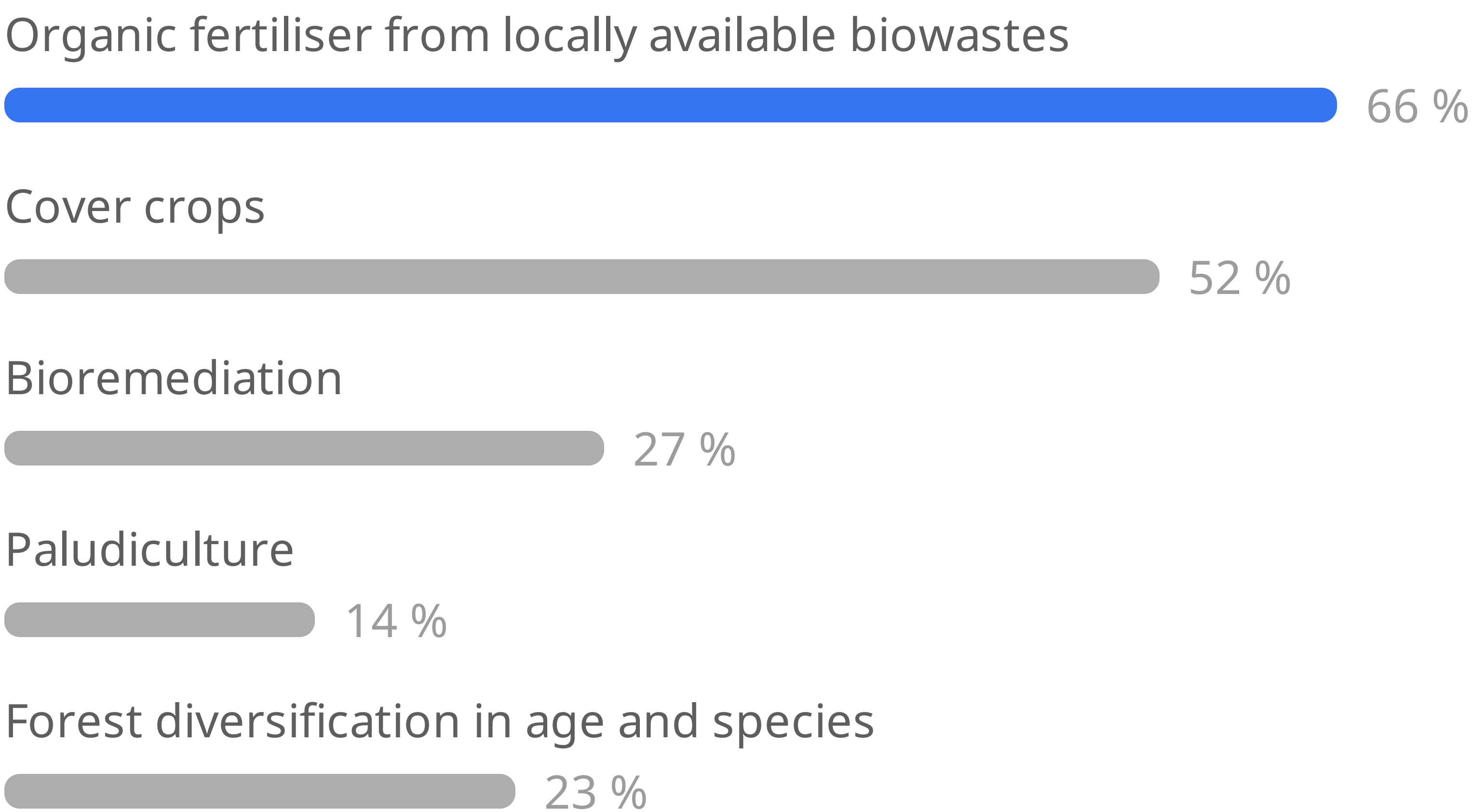
Multiple-choice poll (Multiple answers)

EUROPEAN MISSION SOIL WEEK

0 5 6

Which of the NBS innovations (on its own or combined) do you find more interesting for your context and why?

(1/2)



slido

EUROPEAN MISSION SOIL WEEK

Which of the NBS innovations (on its own or combined) do you find more interesting for your context and why?

(2/2)

0 5 6

Blue green infrastructure

7 %

BOS 8 - Press Room (Building D)

slido

EUROPEAN MISSION SOIL WEEK

If your job role was made into a movie, what would it be called?

005

- "Running into the jungle looking for hidden talent"
- Q - providing tools and support for the teams in action
- TINY TITANS: Chronicles of soil microbial diversity.
- The secretary
- Everything you always wanted to know about professorship but were afraid to ask

Open text poll

EUROPEAN MISSION SOIL WEEK

If your job role was made into a movie, what would it be called?”

(1/2)

038

- Lost Leader
- 7citizen kane
- Soilfluencer
- Lost in translation
- Soil heroes
- do you want to eat?
- Happy goes lucky
- The delayed information
- the ideator
- The puppet master
- The story of Pete...
- Nematode Man II
- Fantastic world
- Soil, the forgotten
- The biochar digger
- The Brain
- Escape
- Agricultural indiana Jones
- Mission possible
- Connector
- Everything, everywhere, all at once
- The Art of Working Blind
- The optimistic policy maker
- State Affairs Impossible
- Queen of the underworld
- Microbe farmer!
- Rocky Balboa

slido

Open text poll

EUROPEAN MISSION SOIL WEEK

If your job role was made into a movie, what would it be called?”

(2/2)

038

- Did you planned today? hahahaha...
- Soily spectacle
- Godmother of Soil
- Fitzcarraldo
- The Martian
- Silence of the soils
- The dot joiner
- How do we avoid the cliff
- Mr. Farm
- Mission impossible
- The Invasive Weed Analyser

What are needs to address the presented challenges on soil health business models

038

include everyone fromt the system
management
regulations
hasing
products
premium
CSRD
regenerative
organic
remuneration/incentives
nonsustainable
sustainable
EU
sector
microbes
make
promoted
managers
building

Make polluters pay

lack of knowlage
price
farming
waste
Regulate
Win
Soil
provided
demand
production
end:
transition
land
way
food
consumer
profitable+regenerative
sustainability
private
clear
services
farmers
practices
peivate
cheaper
paying
instant
ecosystems

Wordcloud poll

EUROPEAN MISSION SOIL WEEK

What do you think the Mission Soil can / should do to promote and support new business models for soil health?

0 4 7

enhance mutiactor collaboration
higher
value
Sponsor pilots
good
topics
lowering
price
Stop focusing on carbon
cost)
pilots
food
prioritise
schemes
friendly
payment
true
spread knowlage
business
parameters
soil
fair
income
projects
prices
soul
priority

Wordcloud poll

EUROPEAN MISSION SOIL WEEK

How can the Mission soil support the transition towards sustainable and inclusive food systems ?

0 2 3

Direct support for farmers

Promoting the approach of one health

Farmers engagement

Creating awareness

Supporting generation renewal and transfer of knowhow

Young people

mainstream sustainable food production

Engagement

Food security

Fund Research

Noriu namo

Nature based solutions

Support for depollution

Ka vakare?

CAP

SFS

group

Policy measures

Plant residues

EGD

Education

Creating

coherence:

working

policy

including farmers

demonstrate good practices in living labs

Soil health monitoring

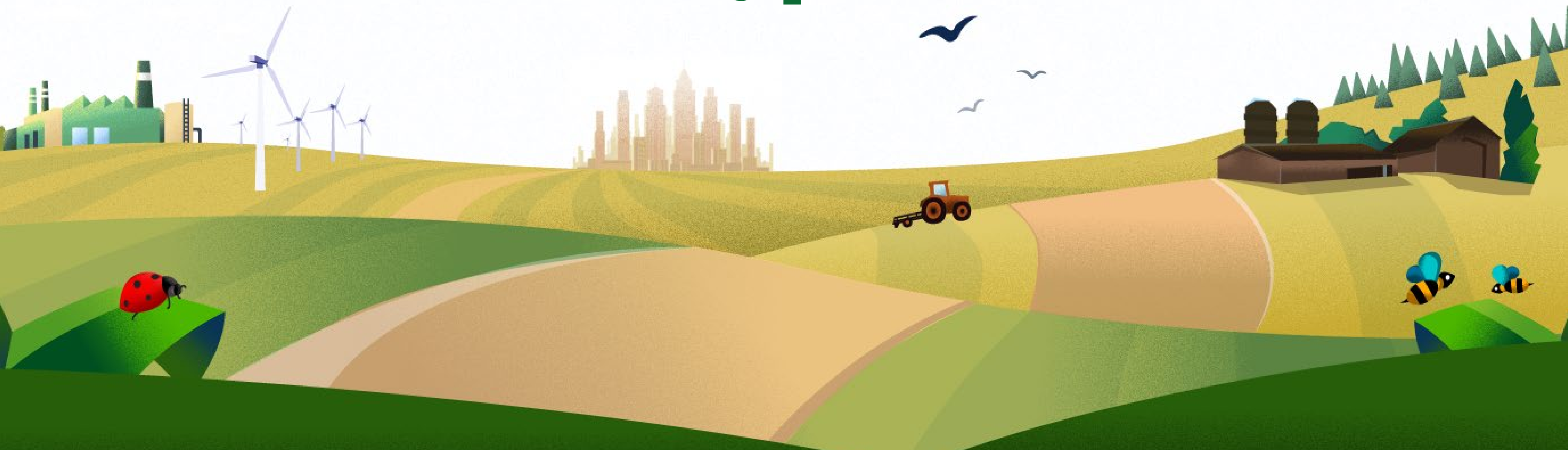
Supporting farmers and foresters eager to innovate

Providing tools to saveguard soils

PREP SOIL

Regions SOIL Needs Assessment

Soil Needs and Drivers of Change Across Europe and Land Use Types



November 2023

Funded by the European Union

Disclaimer

Editors

Bayer Lukas[1]
Bandru Keerthi[1]
Helming Katharina[1]
Gomez Pablo[2]
Sanchez Ivan[2]
Nougues Laura[3]
Maring Linda[3]
Jordan Sabine[4]
Barron Jenny[4]
Keesstra Saskia[5]

1. Leibniz-Centre for Agricultural Landscape Research (ZALF) e.V.
2. Consejo Superior de Investigaciones Científicas (CSIC)
3. Deltares
4. Swedish University of Agricultural Sciences (SLU)
5. Wageningen University & Research (WU)

Table of Contents

Introduction

Key Recommendations

- Soils needs must be taken into consideration when land use decisions are made at all the levels starting from regional to national or European.
- Limiting land abandonment with a clear renaturing plan, monitoring process should be developed to further avoid harmful consequences (erosion, pests etc.,).
- In addition, de-sealing of land should be a high priority and should be a frequently occurring action, especially in rural areas.
- Forest management and restoration activities should be adapted to mitigate the climate change impacts (avoid diebacks, control pests, and release of greenhouse gases).
- Economic incentives for farmers, foresters, land users and city developers should target to further enhance the provision of ecosystem services from soils alongside business activities.
- Multiple income sources in rural areas should be generated and incentivized to avoid the soil degradation processes such as long abandonment.
- Agricultural production should be redirected to stay within the boundaries of ecosystem services from soils.
- New governance models such as soil districts, living labs/light houses should be equipped, maintained from the bottom up with long term sustainability through sufficient finances.
- Soil needs assessment research approach shall be adapted in the other EU Soil Mission Projects.

The European Union's Soil Mission implementation plan lists multiple societal needs from healthy soils. To meet these demands PREPSOIL is supporting the implementation of the Soil Mission by creating awareness and knowledge on soil needs among stakeholders in regions across Europe. PREPSOIL aims to increase awareness of Living Labs as a means of involving stakeholders in soil enhancements across various land use categories (agriculture, forest and natural, urban and post-industrial). Within the framework, as a first step towards developing a long-term collaboration with stakeholders, a stock taking of soil needs in 20 representative regions are conducted (Figure 1). The booklet presents the summary and key recommendations from this analysis.

Soil Needs Assessment Approach

The PREPSOIL research adopted a Soil Needs Assessment (SNA) as a fully interdisciplinary and participatory that combines both natural science knowledge on the functioning of soils and ecosystem services with research methods from the social sciences. The expert knowledge and literature analysis with participatory approaches in the form of workshops to elicit knowledge and to generate awareness and literacy on the importance of soils. The whole research is conducted by employing the five categories of the Driver-Pressure-State-Impact-Response (DPSIR) framework (Figure 2). The framework analyses the systems interactions between human socio-cultural-economic and the soil eco systems. Such drivers differ across European regions; therefore 20 different representative regions across Europe are selected through a study design of a most different case study approach. Our focus was to present cases to reflect the diversity of European land use types, socio-economic and geo-biophysical conditions for soils. Therefore, various agricultural production systems, forestry systems, urban and (post)industrial systems, and mixed land use systems were considered.

The novelty of the SNA is a systems research perspective on soils, focusing on the functioning of social systems and their impacts on the multifunctionality of soils and the ecosystem services. Consequently, SNA systems approach helps us understand and address the drivers for soil management decisions. In furtherance of understanding the societal needs from healthy soils and soil needs from a healthy society, SNA approach describes the complex interaction between society and the soil ecosystem.

In the following pages, the PREPSOIL project presents 20 regions' analysis and results from literature review, workshops, and interviews in the DPSIR categories. The participatory approach used for acquiring the knowledge necessary to fill the DPSIR conceptual framework was a series of workshops and interviews which spanned all of Europe. The workshops served as a way of validating the knowledge acquired from the desk analysis and gathering identified gaps in knowledge More than 500 stakeholders from farmers, policy and government, soil and other advisors, research, business, CSOs and NGOs were interacted during the participatory research process (Figure 3). Regional focused knowledge is co-generated on the existing and emerging socio-economic and geo-biophysical perspectives that determines the health of soils as indicated by their ability to provide ecosystem services. The emerging results were abstracted to a level to find commonalities but also specificities. These findings will be validated in the EU Soil Week (21-23 November, Madrid) and developed into a synthesis report. The synthesis report will elaborate the findings for each land use category.

"Soil Needs are defined as the requirements from existing and emerging socio-economic and geo-biophysical perspectives that determine soil health and related services to human society."

Helming & Bayer

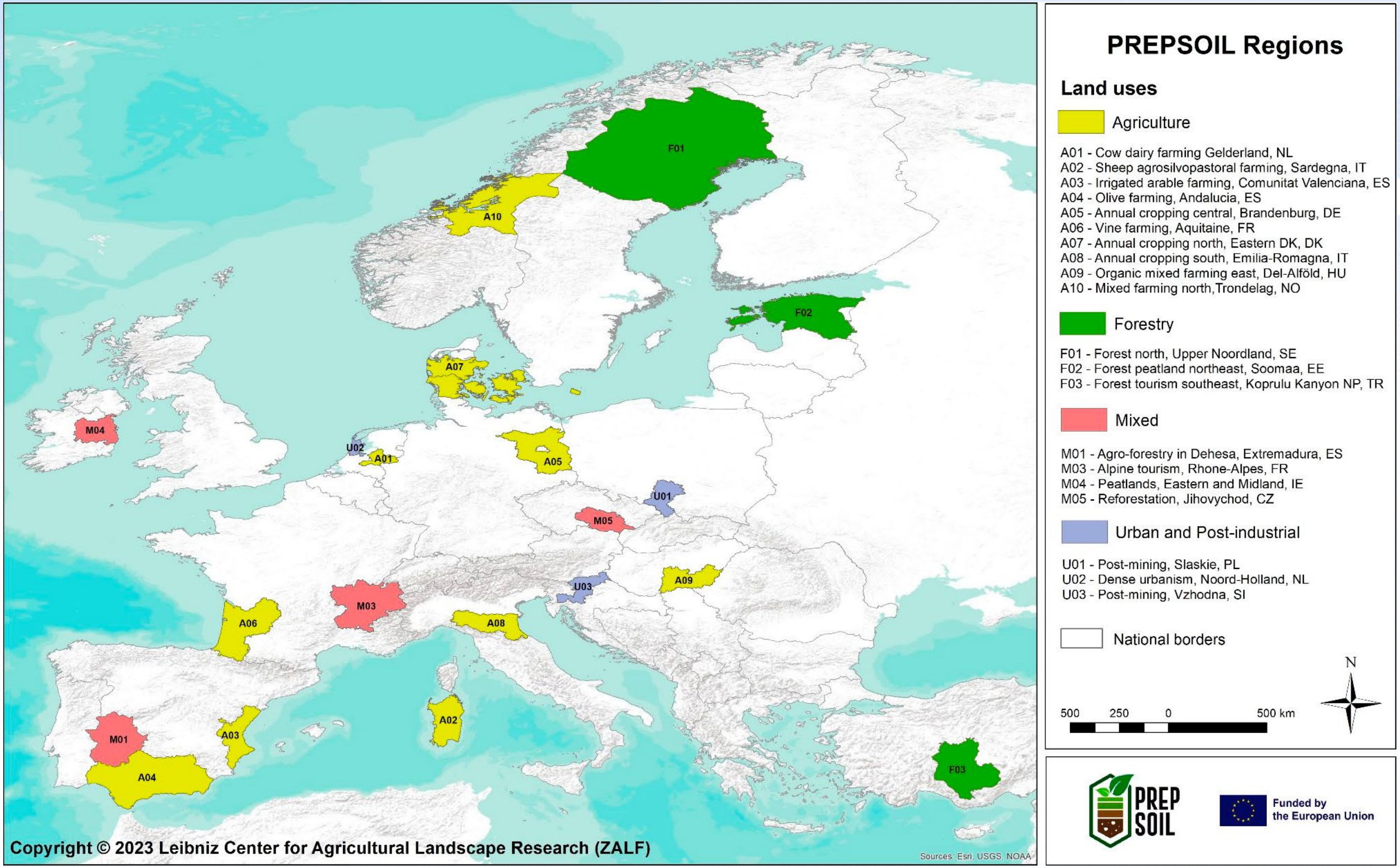


***Figure 1**: Regions of the soil needs assessment in Europe.*

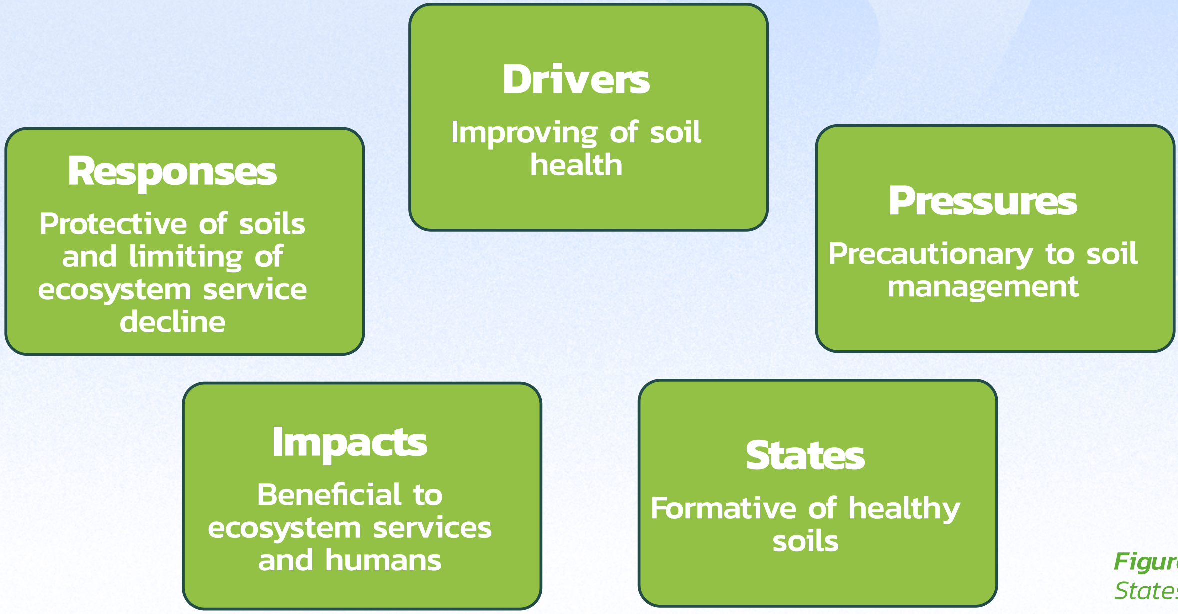


***Figure 2**: PREPSOILs Driver-Pressure-States-Impacts-Response Framework*

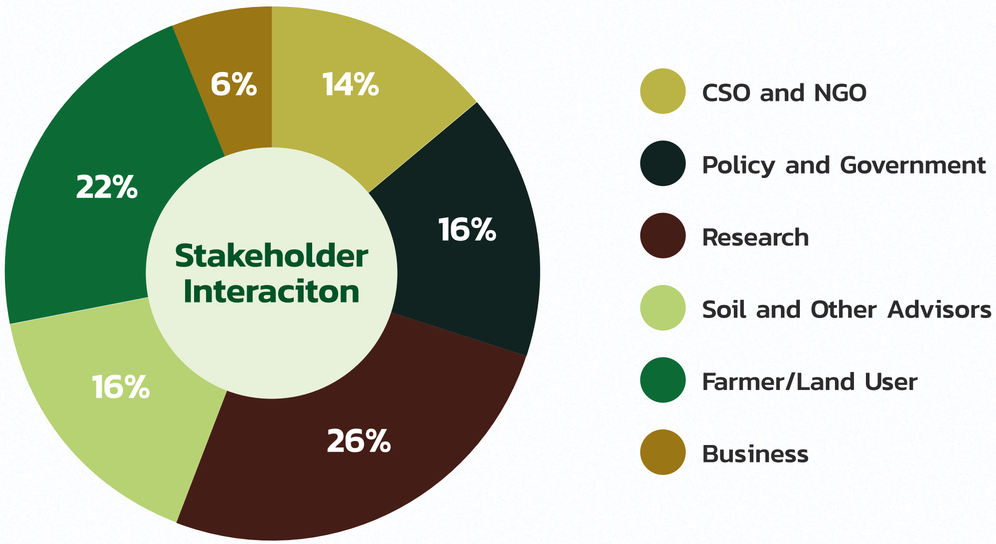


***Figure 3** Stakeholder participated in all the regional soil needs assessment*

Agriculture

PREP SOIL

Regions SOIL Needs Assessment

Agriculture

Cow Dairy Farming

Authors
Menno Diersmann (WENR; menno.diersmann@wur.nl),
Saskia Keesstra (WENR, saskia.keesstra@wur.nl)

Scan the QR Code and visit the Workshop Page to access all the materials

Gelderland (The Netherlands)

REGIONAL INFORMATION

The region was characterized by small-scale farmers, mixed farming systems, incorporating both crops and different Livestock. The landscape was dominated by hedges and thickets, dividing the property of different farmers.

Dominant land use	Dairy Farming
Secondary land use	Arable Farming
Climatic Zone	Cfb = Temperate oceanic climate
Soil WRB classification	Podzol, Fluvisol, Anthrosol
Soil type	Podzol, Fluvisol, Anthrosol
Dominant topsoil texture	Sand (in the higher regions) , Clay (in the valleys)
Soil threat(s)	Too dry (Podzol, Anthrosol), Too wet (Fluvisol), Soil compaction (everywhere)
Representative for regions	areas with intensive dairy farming like Fladers, Northwest Germany and Denmark, but also regions where intensive agriculture is taking place close to Natura2000 areas.

SOIL NEEDS ASSESSMENT

Drivers

- Climate change: extreme droughts, and extreme rainfall events. Mainly sandy soils
- Dutch water system is designed to drain surface water as quickly as possible by ditches and canalized rivers.
- Land consolidation, intensification and specialisation important for the farm profitability
- Policies and conditionality of the CAP (2023 – 2027); crop harvesting dates, fertilizer applications, mono-culture practices,
- Focus on more industry, housing, increased attention for nature areas

Pressures

- Droughts and extreme rainfall cause soil compaction or soil sealing.
- Decreased water quality due to manure surpluses, as water quality should meet the (inter)national standards.
- Increased use of heavy machinery on agricultural land and increase of monoculture, and the practice to let fields lay barren for a while to decrease the chance of pests and
- diseases related to mono-culture cropping.
- Increase of water demand (of agriculture but also due to urbanisation)

State

- Soil compaction, soil sealing, and soil that is too dry or too wet Insufficient water retention capacity
- Changes in water quality and quantity
- Sensors and monitoring programs should create awareness of the soil issues, but the sense of urgency is still not generally seen by landowners/users

Impact

- Decrease in the organic carbon matter in the upper soil, and increasing soil compaction
- The decrease of organic matter in the soil disrupts soil life, causing soil sealing, which leads to run-off of (applied) nutrients.
- The excessive use of fertilisers and pesticides has negatively affected the water quality. Yields became more insecure, especially in monocultures.

Response

- Small-scale initiatives to stimulate sustainable agriculture such as the decrease in use of heavy machinery, crop diversity, animal manure instead of synthetic fertilizers,
- nature inclusive farming on the boundary of nature areas.
- The measures (except carbon sequestration) are currently still based on voluntary actions. Rewards for ecosystem services can stimulate sustainable land use. Subsidies and policies should reward
- farmers for all measures that enhance ecosystem services, and not only a single element as is currently often done.
- Creation of short value chain towards a more sustainable region with a cautious approach of choice and quantity of products.

KEY MESSAGE

- Intensive agriculture, dairy farming and arable agriculture dominant land use, mostly on sandy soils.
- Climate change impacts water availability and soil health: soil compaction in the subsoil of sandy soils and in the topsoil in clay soils. Soil sealing in clayey soils.
- For resilient landscape many small-scale initiatives on extensive, nature-inclusive management are needed.
- Political landscape in the Netherlands and (inter)national regulations makes farming an uncertain business.
- The future of agricultural transition (livestock) is uncertain.
- The transitions towards sustainable soil management is long way.

STAKEHOLDERS INTERACTION

25 April 2023,
InnoFields of Royal Eijkelkamp - Uitmeentsestraat 19, Giesbeek (The Netherlands)

- 2 Policy and government
- 3 Soil and Other Advisors
- 9 Business
- 12 Research community
- 5 Farmer/land Owner
- 5 CSOs and NGOs

Relevant Soil Mission Objectives

- 3. Stop soil sealing and increase re-use of urban soils
- 4. Reduce soil pollution and enhance restoration
- 5. Prevent erosion
- 6. Improve soil structure to enhance soil biodiversity

Funded by the European Union

Agriculture

Sheep Agrosilvopastoral Farming

Authors
Matilde Schirru, Simone Mereu, Antonello Franca, Pasquale Arca, Enrico Vagnoni
(National Research Council - CNR, Sassari, Italy; enrico.vagnoni@ibe.cnr.it)

Scan the QR Code and visit the Workshop Page to access all the materials

Sardegna (Italy)

REGIONAL INFORMATION

This study area is the upper part of the Tirso Valley watershed, located in Central Sardinia and characterized by acidic soils derived from granitic rocks.

Dominant land use	Less than one third of the Tirso valley (104,536 ha) is characterized by silvopastoral land uses, mainly based on dairy sheep farming systems, with a gradient of heterogeneous land use ranging from forest (73,745 ha) to arable lands in the low valley, (more than 75,700 ha).
Secondary land use	Shrublands characterized by Mediterranean maquis, permanent pastures, urban areas.
Climatic Zone	Mediterranean, with a 3 months drought in Summer and rainfall in Autumn and Spring.
Soil WRB classification	Mainly ROCK OUTCROP, LITHIC XERORTHENTS.
Soil type	1. Clay accumulation, shallow water table and salt accumulation; 2. Shallow, moderately fertile and with relatively high amounts of organic matter; 3. Poor fertility, high erosion risk (slope), characterized by stoniness and rockiness; 4. Shallow and acidic soils.
Dominant topsoil texture	Mainly from sandy to sandy-argillaceous soils. Erosion (water), desertification.
Soil threat(s)	Erosion (water), desertification. The region grapples with land abandonment and fire risk.
Representative for regions	ES61 (Andalusia), ES42 (Castilla la Mancha), ES43 (Extremadura) / EL65 (Peloponnese), EL43 (Crete), EL62 (Ionian Islands) / ITF4 (Apulia), ITF6 (Calabria), ITF2 (Molise) / CY (Cyprus). Other agrosilvopastoral Mediterranean regions.

SOIL NEEDS ASSESSMENT

Drivers
The past conversion from woodland to pasture lands, followed more recently by intensification of the sheep farming system and current land abandonment; Climate change leads to increased aridity, prolonged drought periods and extreme precipitation events. The combination of increased drought and extreme precipitation often leads to increased soil erosion.

Pressures
Overgrazing and over-exploitation of the soil (fodder cultivation with intensive techniques) in the past but still visible; High flock density correlated with imbalance in the feed supply chain and lower farm's feed self-sufficiency; The frequency of megafires and extreme wildfires, that are soil erosion multipliers, is increasing with climate change.

State
Low fertility and production potential limit arable crops, implying lower feed-sufficiency level. Natural pasture directly consumed by sheep grazing are dominant. Human activities have shaped the landscape promoting Quercus suber for cork production and lowering the tree density (agroforestry). Land abandonment has cascading effects on gamma biodiversity and fire risk.

Impact
Permanent grasslands provide high soil carbon sequestration potential but the soils' pressures determine: loss of i) soil (5 cm lost since 1980), ii) carbon stocks and iii) biodiversity; decline in water quality (downstream); fire risk increase; reduction in fodder production.

Response
Maintaining pastoralism with site-specific development policies is crucial for maintaining soil and landscape qualitative traits. Encouraging the regrowth and development of potential vegetation in unsuitable soils for grazing (high slopes). To enhance the role of the forest components in the performance of agro-livestock farms and the provision of ecosystem services.

KEY MESSAGE

To promote the improvement and conservation of agrosilvopastoral soils, as well as boosting awareness concerning Soil Health and its proper management at local level represent a strategic objectives. On the other hand, depopulation and abandonment are the main bottleneck for implementing effective solutions for the survival and attractiveness of these areas.

STAKEHOLDERS INTERACTION

23 June 2023
Ollollai, Nuoro Province, Sardegna

- 7 Policy and government
- 4 Soil and Other Advisors
- 1 Business
- 17 Research community
- 6 Farmer/land Owner
- 2 CSOs and NGOs

Relevant Soil Mission Objectives

- 1. Reduce desertification
- 2. Conserve soil organic carbon stocks
- 6. Improve soil structure to enhance soil biodiversity

Funded by the European Union

PREP SOIL

Regions SOIL Needs Assessment

Agriculture

Irrigated Arable Farming

Authors
Artemi Cerdà,
artemio.cerda@uv.es

Scan the QR Code and visit the Workshop Page to access all the materials

REGIONAL INFORMATION

In the Valencia region, the traditional flood irrigation was fed with natural karstic springs, as in many regions around the Mediterranean where limestones are widely-distributed rocks. In the La Ribera district, the river Xúquer allowed a large flood irrigation system that is millennia old. This sustainable system is recently being changed into drip-irrigated areas . The landscape in terms of cultural heritage and attractiveness for agri-tourism deteriorates.

Dominant land use	Irrigated agriculture, adjacent drylands cropping.
Secondary land use	Peri-urban, nature. Rangelands and forest of Pinus halepensis.
Climatic Zone	Mediterranean, 3 months drought in Summer, rainfall in Autum/ Spring
Soil WRB classification	Aridisoles and Entisoles
Soil type	Calcareous silts with low carbon content.
Dominant topsoil texture	loamy clays and sandy clays (depending on geology type)
Soil threat(s)	Soil erosion, soil pollution.
Representative for regions	Irrigated agricultural areas across the Mediterranean in Italy, Greece, Slovenia, Cyprus, France, Turkey, Croatia, Malta, Albania

SOIL NEEDS ASSESSMENT

Drivers

- Climate change-induced droughts and erratic rainfall events with high-intensity rainfall.
- Availability of better-paid work at the coast in the tourism sector.
- Availability of chemical products (since 60's) and drip irrigation (since 80's) for intensive farming.
- Availability of subsidies from the European Union for the implementation of drip irrigation.
- Low prices of agricultural products making intensification necessary.

Pressures

- According to technicians, scientists, and policymakers: Soil erosion and soil compaction and land abandonment
- According to farmers: Aging, the lack of succession, and low income, low prices for products and soil erosion.

State

Soils are considered fertile, but due to millennia-old abuse of tillage, and since 60's herbicides: the soil system and its services: poor condition of natural resources such as biodiversity, quality of water, quality of soil, and damage to the traditional landscape.

Impact

- Water quality and quantity: Chemical agriculture polluted the aquifer. Drying springs due to aquifer depletion.
- Flooding: more flows due to the use of herbicides and the removal of the agriculture terraces.
- Droughts: due to climate change
- Rural development: Irrigation and mechanization are the key factors. Organic farming can be the solution but most of the farmers doubt that without chemicals they can survive within competitive agriculture.
- The yield of crops: Increased.
- Biodiversity: Decreased.

Response

- Encourage young people to participate in the new agriculture, healthier agriculture.
- Reduce soil losses with the use of chopped pruned branches and other mulches.
- Reduce the use of pesticides.
- Increase prices of agricultural products.
- Recover the use of manure, and for this, we need organic farms.
- However, farmers in general are claiming for a chemical agriculture and fair prices and salaries.

KEY MESSAGE

- Organic farmers (5%) and conventional farmers (95%) have contrasting views on the future of agriculture; organic farmers see options for sustainable farming, the conventional farmers have a negative vision for the future.
- All Farmers are claiming for a chemical agriculture and fair prices and salaries.
- All Farmers agree that the damage in nature is high.
- Some soil health restoring methods are acceptable to all farmers (chipped pruned branches) while others are rejected by conventional farmers (remove the use of herbicides, catch crops, or avoid the use of pesticides).

STAKEHOLDERS INTERACTION

14 January 2023,
Xàtiva (Spain)

- 7 Policy and government
- 8 Research
- 6 Soil and Other Advisors
- 23 Farmer/ land Owner
- 5 Business
- 1 CSOs and NGOs

Relevant Soil Mission Objectives

1. Reduce desertification

5. Prevent erosion

Funded by the European Union

PREP SOIL

Regions Soil Needs Assessment

Agriculture

Olive Tree Cultivation

Authors
Iván Sánchez-Castro
(EEZ-CSIC; ivan.sanchez@eez.csic.es),
Ana Segura
(EEZ-CSIC; ana.segura@eez.csic.es)
Pablo Gómez (INIA-CSIC; pablo.gomez@inia.csic.es)
Juan Luis Ramos (EEZ-CSIC; juanluis.ramos@eez.csic.es)

Scan the QR Code and visit the Workshop Page to access all the materials

Andalucia (Spain)

REGIONAL INFORMATION

In Europe, almost 5 million ha are dedicated to olive tree (*Olea europaea* L.) cultivation. Jaén (Spain) was selected as a representative area where olive groves dominate, forming Mediterranean socio-ecological landscapes.

Dominant land use	Agriculture (traditional olive, rain-fed cultivation- 78% of the agriculture land).
Secondary land use	Natural/forestry, urban (rural).
Climatic Zone	Mediterranean: mean annual T 7-18 °C, mean annual precipitation of 400-570 mm; Occasional summer droughts.
Soil WRB classification	Cambisol, regosol.
Soil type	Carbonated materials (marls, limestones and dolostones). High calcium carbonate content and high pH (6-8). Low nutrients content.
Dominant topsoil texture	Mainly coarse texture, high stone content; Loam to clay in some areas.
Soil threat(s)	Water erosion, desertification, salinization, pollution, compaction.
Representative for regions	Andalusia,Castilla la Mancha, Extremadura, Peloponnese,Crete, Ionian Islands, Apulia,Calabria,Molise, Cyprus, Other olive-growing Mediterranean regions in Italy, Greece, Cyprus, Croatia, etc.

SOIL NEEDS ASSESSMENT

Drivers

The main biophysical driver threatening the soil health in olive orchards is the **climate change** (increase of temperatures and decrease of rainfalls). At socioeconomic level, drivers such as the **decreased economic viability**, the **application of traditional deleterious practices** or certain political measures were also identified.

Pressures

Currently, main pressures derive from the **transition of the olive-oil productive sector from traditional model to intensive and super-intensive models**. Intensification practices (mainly the **use of heavy machinery, increase in the use of fertilizers/pesticides and recurrent tillage**) are accelerating soil degradation processes. **CAP-subsidies system** is causing positive and negative pressures.

State

Deterioration of soil health in olive groves has been reported at different levels:
1.**Erosion**: major threat to the sustainability of this crop. 2.**Compaction/degradation of soil structure**: mainly caused by the use of heavy-machinery. Soil water storage capacity is reduced. 3.**SOC depletion** 4.**Decrease in soil biodiversity** 5.**High dependence on EU subsidies.**

Impact

1.**Crop productivity**. 2.**Water regulation:** critical in rainfed olive orchards. 3.**Carbon sequestration and climate change mitigation**. 4.**Regulation of drought, flood and fire risks**: higher frequency and damages caused by these events. 5.**Degradation/contamination of soil and water resources**: affecting their human leisure/economic potential. 6.**Soil biodiversity resources**: reducing beneficial effects on soil resilience/fertility.

Response

Main responses/strategies are: 1.**Societal-political measures**: e.g. policy reforms on soil governance and subsidies-based programs. 2.**Soil literacy – Stakeholders awareness**: e.g. capacity-building/education initiatives, living labs establishment. 3.**Adoption of sustainable/regenerative soil management practices**: e.g. use of vegetable ground covers, soil amendment application, no-tillage, controlling pests and managing water and nutrients efficiently, olive-tree variety optimal selection.

KEY MESSAGE

The massive soil erosion and the lack of water caused by climate change seem to be the main threats for the medium/long-term sustainability of this important economic sector. The adoption of management models promoting olive groves resilience in face of these determining factors seems essential to ensure their socio-economic viability and environmental sustainability.

STAKEHOLDERS INTERACTION

17 March 2023,
Jaén (Spain)

- 5 Policy and government
- 14 Soil and Other Advisors
- 2 Business
- 14 Research community
- – Farmer/land Owner
- 1 CSOs and NGOs

Relevant Soil Mission Objectives

1. Reduce desertification
2. Conserve soil organic carbon stocks
4. Reduce soil pollution and enhance restoration
6. Improve soil structure to enhance soil biodiversity
8. Improve soil literacy in society

Funded by the European Union

Agriculture

Annual Cropping Central Europe

Authors
Lukas Bayer (Lukas.bayer@zalf.de),
Keerthi Bandru (Keerthi.bandru@zalf.de),
Katharina Helming (katharina.helming@zalf.de)

Scan the QR Code and visit the Workshop Page to access all the materials

Brandenburg (Germany)

REGIONAL INFORMATION

The study area Brandenburg is in north-eastern Germany and covers 29.640 km2. It is an excellent case to represent large-scale high technology and industrialized agriculture in Europe. Farm sizes are among the largest in Europe (242 ha). Approximately 45% of its area is dedicated to agricultural land use. Compared to other German states, Brandenburg shows a relatively high share of organic agriculture (12% of the agricultural area), and this share is continuously increasing. Agriculture in Brandenburg is challenged by little rainfall (<600mm annually), mostly sandy soils with little water retention capacity, and frequent drought periods in spring.

Dominant land use	High Tech Agriculture
Secondary land use	Forestry; metropolitan region Berlin is spreading into Brandenburg
Climatic Zone	Continental
Soil WRB classification	Luvisols
Soil type	Dominantly loamy sand, sandy loam; 4% organic soils
Dominant topsoil texture	Loamy sand and sandy loam
Soil threat(s)	SOC decline, compaction, biodiversity decline, soil erosion (water, wind, tillage); decreasing water retention capacities
Representative for regions	Regions in Europe with large scale, large field sizes, highly industrialized, similar to Po Valley, Veneto, Emilia-Romagna, Lombardy, and Normandy, in Eastern Europe as they share a common heritage of eastern block association.

SOIL NEEDS ASSESSMENT

Drivers
- Climate change-induced droughts, erratic rainfall.
- Unfavourable geophysical features- poor soils, poor accessibility, low fertility
- Large-scale high technology and industrialized agriculture, large farm sizes (242 ha), narrow crop rotation (maize, wheat, rye)
- Farmers attributes (education, age, know-how, political attitudes)
- Lack of adequate extension services and research transfer to farmers
- Policies and conditionality of the CAP (2023 – 2027)
- Increased demand for regional products, animal products, biomass for energy, food waste, increased industrial use of biomass

Pressures
- Precision farming, uptake of autonomous machineries, No-till practices, Biochar, Agri solar panels
- Context adapted agricultural practices (conditions in soil and weather when choosing crops and rotations)
- Flexible site adapted soil management
- Soil as a crop location factor

State
The state of Brandenburg soils in terms of soil health for agricultural production is determined by:
- Insufficient water retention capacity in the root zone
- Low and medium levels of soil organic carbon

Impact
- Ever-increasing economic vulnerability of farms.
- Price shocks from trade, dependency on cap payments impacts on socio-economic viability of the farming. Unforeseeable dynamics of the CAP's expansion of the second pillar and the changes, worried many participants as their planning capacity is severally impacted, leading them to consider moving out of the farming sector.
- Eco-system services, soil organic matter and soil fertility are negatively impacted

Response
- Soil management practices (no-till, improve soil structures) should be adapted to increase the water retention capacity of soils.
- A diversified product portfolio as adaptation strategy can meet the societal consumption preferences and protect against price shocks.
- Reconnecting the urban-rural linkages is of special relevance for Brandenburg as Berlin is in its centre.
- Digitalization, assigning new roles to advisors, such as facilitator and intermediaries a
- In response to the increasing land prices the parliament of Brandenburg introduced the agricultural structure act, which aims at limiting land investment coming from real estate companies
- To strengthen the family-owned farms, protect the rural farming heritage, maintain the agricultural landscape has recreational value.
- A major influence for farmers was their desire for self-determination to not be overly regulated and carrying burdens of bureaucracy for their activities.

KEY MESSAGE

- The farming is affected by a strong path dependency, such as ownership consolidation in the GDR which resulted in large farm sizes that shape farm management decisions.
- Innovation activities should focus on the improvement of a knowledge transfer system, changing spatial patterns and landscape elements, alternative income sources, and establishment of regional value chains.
- Adaptation measures should be prioritised to improve water retention capacity and limit erosion (no-till practices, agroforestry)
- Digitalisation in agriculture will play key role in the future of the farming system in Brandenburg and its focus on efficient production to improve ecosystem services from soils, e.g. precision farming.

STAKEHOLDERS INTERACTION

26 May 2023,
Münchenberg (Germany)

- 2 Policy and government
- 2 Soil and Other Advisors
- 2 Business
- 5 Research community
- 9 Farmer/land Owner
- 2 CSOs and NGOs

Relevant Soil Mission Objectives

- 2. Conserve soil organic carbon stocks
- 5. Prevent erosion
- 6. Improve soil structure to enhance soil biodiversity

Funded by the European Union

Regions SOIL Needs Assessment

Agriculture

Wine Farming

Authors
Lisa Viry (Acta),
Flavien Poinçot (Acta).
flavien.poincot@acta.asso.fr

Scan the QR Code and visit the Workshop Page to access all the materials

Aquitaine (France)

REGIONAL INFORMATION

Bordeaux vineyard is a well-known vineyard with many different terroirs, related to various pedo-climatic context, facing climate change and a difficult socio-economic context.

Dominant land use	Agriculture: wine, cereals, grassland, fodder
Secondary land use	Urban and peri-urban
Climatic Zone	Oceanic climate
Soil WRB classification	Mainly ROCK OUTCROP, LITHIC XERORTHENTS.
Soil type	Limestone and clay bedrock, sandy loam soil, silt-clay soils and graves (gravel and pebbles, often mixed with sand and clay),
Dominant topsoil texture	Mainly from sandy to sandy-argillaceous soils. Erosion (water), desertification.
Soil threat(s)	Mainly Sandy loam, silt-clay, graves
Representative for regions	Based on its climate, can be representative of other vineyards near the Atlantic coast and some regions in the north of Spain and north of Portugal.

SOIL NEEDS ASSESSMENT

Drivers
Climate change is the main biophysical driver identified during the evaluation process. The growing demography of the region, a growing societal demand for a healthy environment and sustainable agriculture, and the decline of wine consumption on the domestic market are the main socio-economic drivers identified.

Pressures
Rising in temperatures, changes in rainfall patterns and droughts that can lead to water scarcity, and increase in frequency and intensity of extreme events and climatic accidents (late frost, hail, drought).
Societal demand for reduction of pesticide use, urban sprawl leading to artificialisation, and financial challenges faced by winegrowers.

State
Land artificialisation of 0.9%/year in Gironde between 2008 and 2018. Significant variability in soil types and states within the vineyard. Main changes in soil states identified as a concern for the future are the loss of soil biodiversity and organic matter, soil compaction and the potential accumulation of pesticides.

Impact
Impact on soil capacity to supply water (and minerals) to the vines is the main concern in the context of climate change. Soil states also impacts yield and quality of grape production, carbon sequestration and storage capacity, and plays a role in the unique cultural identity of the vineyard.

Response
Several initiatives exist at the national and regional level to foster the adoption of sustainable practices in the vineyard (81% of the vineyard was under permanent grass cover in 2019). Efforts in research and in fostering interaction between researchers, advisors and winegrowers are also made and need to be strengthen.

KEY MESSAGE

Main levers identified are: research and development in real conditions (data and references, operational tools), co-creation approaches and demonstration sites (fostering dissemination and peer-to-peer exchange), economic support (public policies, label specifications, role of retail sector), a strong technical support (requires human resources) and more internal expertise on soil within organisations.

STAKEHOLDERS INTERACTION

April, 26th ; Maison de l'Agriculture et de la Forêt, Bordeaux, France.

- 3 Policy and government
- 6 Soil and Other Advisors
- – Business
- 11 Research community
- 3 Farmer/land Owner
- 4 CSOs and NGOs

Relevant Soil Mission Objectives

- 2. Conserve soil organic carbon stocks
- 4. Reduce soil pollution and enhance restoration
- 5. Prevent erosion
- 6. Improve soil structure to enhance soil biodiversity
- 8. Improve soil literacy in society

PREP SOIL

Regions SOIL Needs Assessment

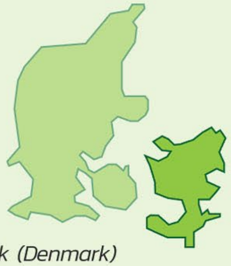
Agriculture

Annual Cropping North

Author

Jorge F. Miranda-Vélez (jorge_mv@agro.au.dk), Aarhus University Department for Agroecology

Scan the QR Code and visit the Workshop Page to access all the materials



Eastern Denmark (Denmark)

REGIONAL INFORMATION

East Denmark is characterized by loamy soils, and a warmer, drier climate than the rest of the country. Approx. 60% of the land area is agricultural, dominated by large single-owner farms focused on cereals like winter wheat and barley.

Dominant land use	Arable agriculture (59% land area), primarily grains/cereals.
Secondary land use	Urban, Managed forest
Climatic Zone	Atlantic North, Continental.
Soil WRB classification	Luvisols, Cambisols, Regosols.
Soil type	Post-glacial moraine.
Dominant topsoil texture	Loams, loamy sands and sandy loams.
Soil threat(s)	Soil organic carbon loss, nutrient loss, compaction (topsoil and subsoil), water erosion, reduced water retention capacity, reduced soil fertility.
Representative for regions	Regions with similar soil and climate characteristic, where annual cropping is also a dominant land use, e.g. Scania (Sweden), Southern Finland, Northern Germany, Northern France, Poland.

SOIL NEEDS ASSESSMENT

Drivers

- Intensification of agriculture after the 1950's, with wide-scale mechanization and consolidation into large farms focused on high-yield annuals.
- Nutrient pollution in vulnerable aquatic ecosystems which led to strict nutrient regulations after the 1980's
- Climate change (milder winters, drier growing seasons)

Pressures

- Excessive tillage and heavy machine traffic (negative)
- Minimal or zero tillage, e.g., as part of Conservation Agriculture (positive)
- Excessive use of mineral and carbon-poor fertilizers (negative)
- Organic management and principles (positive)
- Low crop diversity (negative)
- Periods of grass cultivation, including for grass seed production (positive)

State

- Low SOC content
- Nutrient depletion
- Soil compaction
- Reduced water holding capacity
- Erosion risks from water and tillage.

Impact

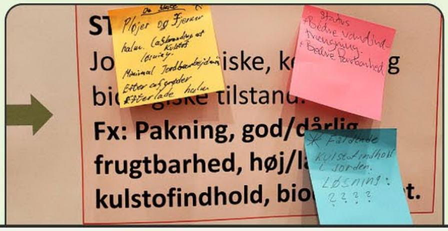
- Reduced fertility and yield stability affect provision of cultivated plants (for nutrition, materials and energy)
- Nutrient pollution affects general provision of surface and groundwater.
- Low crop and soil biodiversity affect pest and disease control (in crops).
- Soil carbon loss and GHG emissions affect the chemical composition of the atmosphere.

Response

- Continued increase in farm sizes and intensive practices.
- New investments towards improving soil health (e.g., Conservation or Precision agriculture).
- Faster change in large corporate farms and with younger farmers.
- Increased policy focus on soil health and climate goals.
- Novel forms of research (e.g., Living Labs).

KEY MESSAGE

Research and innovation in East Denmark should prioritize the scientific and practical validation of emerging agricultural practices (Regenerative practices, Conservation Agriculture, Precision Agriculture, etc.). Policy makers, advisory services and farmer's schools should be involved in the research along with researchers and farmers to help guide Denmark's comprehensive regulations.



STAKEHOLDERS INTERACTION

April 13th, 2023 at AU Flakkebjerg and May-June Online

- 2 Policy and government
- 5 Soil and Other Advisors
- – Business
- – Research community
- 8 Farmer/land Owner
- 3 CSOs and NGOs

Relevant Soil Mission Objectives

- 2. Conserve soil organic carbon stocks
- 5. Prevent erosion
- 6. Improve soil structure to enhance soil biodiversity
- 7. Reduce the EU global footprint on soils
- 8. Improve soil literacy in society

Funded by the European Union

PREP SOIL — Regions SOIL Needs Assessment

Agriculture

Large Scale Annual Cropping

Authors
Re Soil Foundation

Scan the QR Code and visit the Workshop Page to access all the materials

Emilia-Romagna (Italy)

REGIONAL INFORMATION

The most fertile arable land of Italy, extending over the provinces of Emilia-Romagna, surrounded by the Adriatic Sea, the Appennines and the Po river.

Dominant land use	Agriculture, croplands
Secondary land use	Urban/industrial
Climatic Zone	Temperate subcontinental
Soil WRB classification	Cambisols
Soil type	More than 210 identified: mainly alluvial origin
Dominant topsoil texture	Variable texture, predominantly medium to fine, with a high fraction of alterable minerals and carbonates
Soil threat(s)	Soil sealing; soil organic matter loss; drought; flood; soil erosion; soil pollution; soil salinity; functional soil biodiversity deterioration
Representative for regions	-

SOIL NEEDS ASSESSMENT

Drivers
The extreme climatic events have accentuated:
- Rainfall is concentrating in shorter periods, resulting in longer droughts and higher flooding hazards. Overall reduction of snowfalls;
- Temperature: the medium annual temperature and the minimum temperature have increased.
- Urbanisation keeps consuming soil for infrastructures;
- Shift toward industrial production system.

Pressures
Building activity and infrastructures expansion; overall division of animal farming and agricultural production together with misalignment in animal manure cycling; landscape elements renewal (hedgerows and buffer zones); mechanization, technologies and land management.

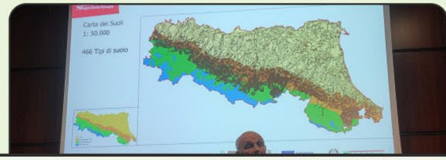
State
High rate of soil sealing (net soil consumption of +658 ha); low soil organic matter content (0,98-2,26 %) which keeps decreasing.

Impact
Reduction of water retention capacity and availability, soil stability and structure which are represented by the numerous lanslides and floodings occurred; Overall, the quality of the soil's structure is lowering and the nutrients mineralization is faster.

Response
The Regional law L.R. 24/2017, taking effect by 1.1.2024, introduced a maximum of 3% of consumable land, consequently reducing regional land potentially by 70% the hectares of transformable land. In the strategic plan for CAP 23-27 of Emilia-Romagna are listed specific measure to incentivize the use of conservative practices for soil.

KEY MESSAGE

Identified needs include: further research on conservative agricultural practices and surrogates of manure; establishment of MRV (Measurement, Reporting, and Verification) methodologies for monitoring and results verification; development of Carbon Farming schemes



STAKEHOLDERS INTERACTION

24 May 2023,
Rimini (Italy)

- 4 Policy and government
- 7 Soil and Other Advisors
- 7 Business
- 3 Research community
- 10 Farmer/land Owner
- 22 CSOs and NGOs

Relevant Soil Mission Objectives

- 3. Stop soil sealing and increase re-use of urban soils
- 4. Reduce soil pollution and enhance restoration
- 5. Prevent erosion

Agriculture

Mixed Farming East

Authors
Judit Berényi-Üveges , Korinna Varga
Hungarian Research Institute of Organic Agriculture,
judit.berenyi.uveges@biokutatas.hu

Scan the QR Code and visit the Workshop Page to access all the materials

Del-Alföld (Hungary)

REGIONAL INFORMATION

The selected, Dong creek region is a part of the Sand Ridge that stretches across the Hungarian Great Plain in the Danube-Tisza Interfluve.

Dominant land use	cropland, field crop production
Secondary land use	grassland with extensive livestock farming, fruit and vine
Climatic Zone	IPPC climatic zone: Warm Temperate Dry
Soil WRB classification	Arenosols, Cambisols
Soil type	quicksand, humus sand
Dominant topsoil texture	sand, loamy sand
Soil threat(s)	Wind erosion and desertification due to climate change and historical change in water management.
Representative for regions	Sandy part of Szabolcs-Szatmár Bereg in Hungary, Regions having drought issue on sandy soils.

SOIL NEEDS ASSESSMENT

Drivers
The main problem is climate change (warming and decrease precipitation and change in precipitation pattern) followed by change in water management (draining water away from the region) and changes in land use (intensive crop production, afforestation).

Pressures
As a result of changes in water management and land use, territory of arable land has increased, but the natural water reservoirs region has been dried up. Drought further increases water use, which further lowers groundwater level. Farming practices use intensive tillage with ploughing and disking that deteriorate soil structure, soil organic matter and biodiversity.

State
Increasing number of serious wind erosion events damaging crops and infrastructure has been reported.

Impact
Effect of water shortage can be seen on the vegetation and dried up saline lakes, but it also has a great impact on the agricultural production. Yield stability decreased due to extreme weather events and longer dry periods.

Response
Most people agree that keeping precipitation in place would be one of the most important measures. A local initiative consisting of local farmers has already started a small water retention project as pilot. **Workshop participants appreciate the efforts of agricultural policy to promote the change, but the ways of communication and implementation has to be improved.**

KEY MESSAGE

Farmers have to apply soil conservation techniques adapted to the region and sandy soils to restore soil structure, increasing biodiversity and organic matter. Restoration of hedge rows and trees is also important for example controlling wind speed and providing habitats for wildlife and biodiversity. It has to be accompanied with changes in water management retaining water in the landscape.

STAKEHOLDERS INTERACTION

24th May 2023
Kujáni Tanya, Kecskemét, Hungary

- 4 Policy and government
- 5 Soil and Other Advisors
- – Business
- 13 Research community
- 8 Farmer/land Owner
- 3 CSOs and NGOs

Relevant Soil Mission Objectives

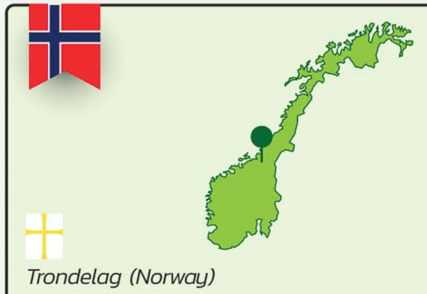
- 1. Reduce desertification
- 2. Conserve soil organic carbon stocks
- 5. Prevent erosion
- 6. Improve soil structure to enhance soil biodiversity

Agriculture

Mixed Farming North

Authors
Kamilla Skaalsveen, Adam O'Toole (NIBIO)

Scan the QR Code and visit the Workshop Page to access all the materials



REGIONAL INFORMATION

The study area Brandenburg located in north-eastern Germany and covers 29.640 km2. It is an excellent case study to represent modern agriculture in Europe, because it is an agricultural state characterized by intensive use; approximately 45% of its area is dedicated to intensive agricultural land use. Compared to other German states, Brandenburg shows a relatively high share of organic agriculture (12% of the agricultural area), and this share is continuously increasing. Brandenburg is representative for very large-scale high technology and industrialized agriculture. Farm sizes are among the largest in Europe (242 ha).

Dominant land use	Production forest (15 047 km2)
Secondary land use	Agriculture (1 813 km2) consisting of 61% gras production, 27% cereals, 11 % grasland (for grazing), 1,2 % potato and vegetable production, 0,1 % berries and fruit production
Climatic Zone	Alpine north/atlantic north
Soil WRB classification	Stagnosol (dominant WRB), Gleysol, Cambisol, Arenosol, Histosol, Podzol, Leptosol, Regosol, Phaeozem, Fluvisol, Planosol, Umbrisol
Soil type	Agricultural soil
Dominant topsoil texture	Silty loam/clay loam
Soil threat(s)	High precipitation rates, poor drainage, soil compaction (saturated soil during harvest), soil erosion, soil sealing. Part time farming, intensive agriculture, limited time to spend on farm work, sometimes lacking/to small economic incentives, high pressure on agricultural land.
Representative for regions	Regions in Europe with Cereal production and mixed farming at high latitudes.

SOIL NEEDS ASSESSMENT

Drivers

- Political decisions, affecting pricing and agricultural agreements/settlement, Canalization policy, levelling of soils, production subsidy measures are not practical oriented, poor agriculture infrastructure.
- Distance between decision-makers and farmers, poor link between theory and practice
- Climate change- short growing season, unpredictable rain.
- Land use change from agriculture to other, expensive heavy machinery.
- Farming is part time occupation, shift towards mixed farming (livestock and grain)

Pressures

- Decreased mixed farming (removal of livestock)
- Increase in the lease land, lack of knowledge and prioritization for soil health
- Absence of crop rotation and crop biodiversity
- Poorly maintained drainage
- Warmer and dry seasons has positive pressure with more time for farming activities
- Investments in the biogas industries

State

- Slowly decreasing soil organic carbon, reduced soil fertility
- Reduced biodiversity
- The workability of the soil was also decreasing, requiring more horsepower and effort to till the soil
- Soil compaction, Soil sealing and permeant loss of fertile soil, land abandonment

Impact

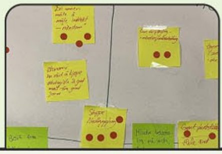
- Soil fertility, functioning and resilience (to floods and droughts), plant root growth, soil gas exchange capacity, microorganisms' access to
- "food" (as straw is heavily degradable and often removed).
- Reduced water infiltration, storage capacity, increasing surface runoff, the risk of nutrient leaching, water eutrophication affecting wild
- salmon.

Response

- Diversity, cover crops and crop rotations (with e.g. wheat, peas, beans and oilseed rape), "green soil cover", permanent grassland, organic inputs
- Knowledge demand on soil health improving measures- cover crops in high altitudes, bio-manure applications, biochar application, farm
- equipment and about the status of soil health.
- Organic residues from the biogas facilities, is possibly easier to transport than manure, creating new opportunities.
- Good links between farmers, extension services, decision makers and researchers
- Regulations related to subsidies need to be flexible.

KEY MESSAGE

- Agriculture in Trøndelag is diverse with dairy and meet, grain (barley), and vegetables. Soil health is affected with low organic carbons, soil
- compaction from heavier machinery, poorly drained fields, increase in leased land.
- The regional policies need to adopt to local farmer demands
- Raising awareness amongst politicians, consumers and producers is key to get soil health. Establishing farmer engagement, and co-op
- farming, A labeling scheme for soil health on products.



STAKEHOLDERS INTERACTION

27-28 March 2023,
Skjetlein and Mære, Norway

- 2 Policy and government
- 11 Soil and Other Advisors
- 5 Business
- 4 Research community
- 8 Farmer/land Owner
- 5 CSOs and NGOs

Relevant Soil Mission Objectives

- 2. Conserve soil organic carbon stocks
- 3. Stop soil sealing and increase re-use of urban soils
- 4. Reduce soil pollution and enhance restoration
- 5. Prevent erosion
- 6. Improve soil structure to enhance soil biodiversity
- 8. Improve soil literacy in society

prepsoil.eu @prepsoil in /company/prepsoil @prepsoil zenodo PREPSOIL

Funded by the European Union

Mixed

PREP SOIL

Regions SOIL Needs Assessment

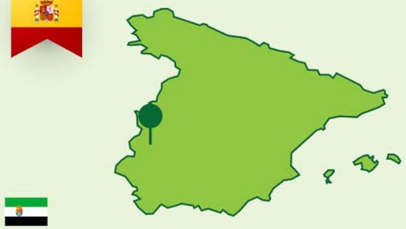
Mixed

Agro-Forestry in DEHESA

Authors

Concha Civantos
(concha.civantos@fundecyt-pctex.es) and
Mayte Gallego (mayte.gallego@fundecyt-pctex.es)
Foundation FUNDECYT SCIENTIFIC
AND TECHNOLOGICAL PARK OF EXTREMADURA
(FUNDECYT-PCTEX)

Scan the QR Code and visit the Workshop Page to access all the materials



Extremadura (Spain)

REGIONAL INFORMATION

The DEHESA is a centennial land system composed by scattered oak trees and annual native pastures extensively grazed by autochthonous livestock, being part of the cultural legacy of Extremadura region.

Dominant land use	Extensive grazing
Secondary land use	Self-consumption agriculture
Climatic Zone	Mediterranean
Soil WRB classification	Leptosol, Cambisol and Regosol
Soil type	Shallow, sandy-loam textured, slightly acidic and relatively poor in nutrients
Dominant topsoil texture	Sandy-loam
Soil threat(s)	Erosion, compaction, lack of fertility
Representative for regions	Extremadura (ES), Andalusia (ES), Alentejo (PT), Castilla-La Mancha (ES), Castilla y León (ES)

SOIL NEEDS ASSESSMENT

Drivers

Regarding environmental drivers in Extremadura, most of them are consequence of climate change: drought risk, flood risk, fire risk, frequency of extreme weather, etc., with much longer dry periods. On the other hand, as Socioeconomic driver, **low farm profitability** and **lack of generational replacement** have been also identified.

Pressures

The need of cultivation. The low profitability of many farms forces their farmers to cultivate their soils to avoid buying external feed. The Dehesa soil (shallow and relatively poor in nutrients and organic matter) is not suitable for being cropped regularly. Even the occasional crops can cause significant loss of soil, nutrients and organic carbon

State

The current state of Dehesas is not satisfactory yet because they are overcoming former processes of land use intensification in parallel with current livestock mismanagement in many farms. Although their normal edaphic conditions are not so exigent, the optimum conditions could be only reached when every farm has a reasonable tree density.

Impact

The impacts suffered by the Dehesa system are a consequence of socio-economic drivers happened overall during the 20th century and in the recent decades: reduction of biomass production, soil erosion, less water quality and availability, loss of biodiversity, increase of the external dependence of the farms and loss of reputation.

Response

- **Zero tillage**.
- **Smart grazing.** Farmers must be trained in an intelligent, sustainable and regenerative grazing.
- **Soil protection**. In degraded areas it is suggested the construction of check-dams to avoid soil losses during torrential events.
- **Tree regeneration.** It is necessary to implement regeneration and afforestation techniques with support irrigation.

KEY MESSAGE

Dehesa system must overcome land mismanagement practices that provoke soil degradation and bad reputation as well as new threats induced by the effects of climate change and loss of rural population that threaten the current scenario. The use of new technologies and the co-design of solutions seem to be essential for the sustainability of this ancestral land system.

STAKEHOLDERS INTERACTION

13 April 2023
Badajoz (SPAIN)

- 3 Policy and government
- - Soil and Other Advisors
- 3 Business
- 6 Research community
- 2 Farmer/land Owner
- 1 CSOs and NGOs

Relevant Soil Mission Objectives

1. Reduce desertification
2. Conserve soil organic carbon stocks
5. Prevent erosion
6. Improve soil structure to enhance soil biodiversity
8. Improve soil literacy in society

PREP SOIL

Regions SOIL Needs Assessment

Mixed

Alpine Tourism

Authors
Lisa Viry (Acta),
Flavien Poinçot (Acta)
flavien.poincot@acta.asso.fr

Scan the QR Code and visit the Workshop Page to access all the materials

Rhône-Alpes (France)

REGIONAL INFORMATION

The Lautaret-Oisans region is located in the French Alps (mainly the Northern Alps). Snow-related tourism is a major economic driver, threatened by climate change.

Dominant land use	Natural, agriculture (pastoral)
Secondary land use	Recreative (skiing, biking, etc.)
Climatic Zone	Mountain climate / continental
Soil WRB classification	(Dystric) Cambisols, Colluvic Regosols, Hyperskeletic Leptosols
Soil type	Variable. Limestone, silt, shallow, acidic soils with calcareous stones; glaciers
Dominant topsoil texture	Variable. Silt loam, silty clay, silty clay loam, with stones
Soil threat(s)	Climate change (erosion, changes in the cryosphere and water resources, increase in climatic hazards and risks in the high mountains, increase and elevation of wooded areas, artificialization of valley bottoms, greening) Mass tourism (urbanisation, biodiversity degradation, erosion)
Representative for regions	(North) alpine regions, other mountain regions with snow-related tourist activities

SOIL NEEDS ASSESSMENT

Drivers
Climate change and its consequences (reduced snow cover, greening phenomenon, ...) is the main biophysical driver identified. The importance of tourism to the region's economy, the decline in the local population and the high number of tourists requiring short-stay accommodation are the main socio-economic drivers identified.

Pressures
Tourism's response to climate change currently includes artificial snowmaking or the development of alternative activities (e.g., hiking) that can lead to high tourist flows in sensitive areas (natural, forest, or pastoral). Drivers also led to conflicts over the use of water resources (domestic, agricultural, and pastoral use, hydroelectric production, tourism).

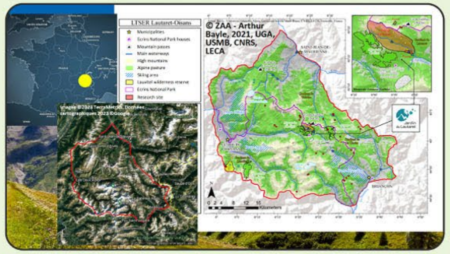
State
Melting of permafrost affect soil stability. Soil sealing rate is 1.29% in mountain resorts, 1.05% in mountain municipalities. Some impacts on soil compaction, pollution, biodiversity and salinisation need to be further studied. Expansion of vegetation partly explains a reduction in soil loss and improvement in soil characteristics in some areas.

Impact
Soil degradation:
- affect fodder production in the area;
- reduces the capacity of ecosystems to control erosion and natural hazards (tourism infrastructures and activities)
- reduces the cultural and recreational services with potential economic impact on local communities (e.g., closure of a shelter due to destabilisation of the bedrock)

Response
While soil preservation may not be the first priority in the area, several solutions (such as nature-based solutions) were mentioned by the stakeholders. Several initiatives have already been implemented, such as soil restauration with local seeds, territorial planning with citizen involvement to reduce artificialisation, or awareness raising actions.

KEY MESSAGE

- Collecting data and developing knowledge at the local level.
- Raising public awareness (on how and why preserve soil) using strategies designed for different target audiences, including local political decision-makers.
- Involving citizen in local governance
- Technical and economic support to adopt new practices.



STAKEHOLDERS INTERACTION

May 10th 2023
Grenoble, France.

- 2 Policy and government
- 2 Soil and Other Advisors
- – Business
- 4 Research community
- 5 Farmer/land Owner
- 3 CSOs and NGOs

Relevant Soil Mission Objectives

- 2. Conserve soil organic carbon stocks
- 3. Stop soil sealing and increase re-use of urban soils
- 4. Reduce soil pollution and enhance restoration
- 5. Prevent erosion
- 6. Improve soil structure to enhance soil biodiversity
- 8. Improve soil literacy in society

PREP SOIL

Regions SOIL Needs Assessment

Mixed

Peatlands

Authors

Niall Curley & Branwen Miles, Copacogeca (Niall.Curley@copa-cogeca.eu, Branwen.Miles@copa-cogeca.eu) and Sabine Jordan, Swedish University of Agricultural Sciences (sabine.jordan@slu.se)

Scan the QR Code and visit the Workshop Page to access all the materials

Eastern and Midland (Ireland)

REGIONAL INFORMATION

Ireland has transitioned away from the use of peat. Realigning policy through mediation will help to mitigate and reverse damaging activities on peatland habitats.

Dominant land use	Agriculture, forestry
Secondary land use	Previously energy peat production
Climatic Zone	Temperate
Soil WRB classification	Histosols
Soil type	Peat
Dominant topsoil texture	Peat; often highly decomposed
Soil threat(s)	Drainage of peatlands led to peat shrinkage, compaction, subsidence, erosion and greenhouse gas emissions
Representative for regions	Midlands North West Region

SOIL NEEDS ASSESSMENT

Drivers
Overgrazing, agricultural drainage, commercial forestry plantation and domestic and commercial turf cutting affect Irish blanket bogs and associated peatlands. Those land use activities result in biodiversity loss, soil erosion, decline in water quality, reduction in carbon sequestration and increased rate of carbon emissions.

Pressures
Farmers spent their lives extracting peat and now they rewet. This should be seen as a benefit for the community. Regarding the communication around rewetting and restoration, many farmers fear what it means for their farm and highlight the importance of getting the correct information from the right people. There is many miscommunication, which is creating fear.

State
Today, the status of Ireland's blanket bogs is considered 'bad' in terms of condition. This indicates that many blanket bogs are losing important species, releasing carbon to the environment, and providing sub-optimal water quality. Many farmers want to rewet their drained peatlands but lacking knowledge and communication.

Impact
A lot of income in this region comes from intensive farming. Peatland rewetting would reduce farming intensity but also income in the beginning before new economic valuable land uses on wet peatlands have been installed. There are many farmers whose rewetting will impact neighbouring farms who are not involved in rewetting programs. They need to be informed.

Response
To conserve and improve peatlands is to work with farmers and local communities by developing measures, such as base line site surveys, ecological assessments, training for conservation actions, fire prevention and water management. The role of climate officers and effective communication with farmers was emphasized, along with the need for realistic and less bureaucratic approaches.

KEY MESSAGE

The Irish Climate Action Plan set targets and measures to reducing agricultural production on peatlands under grassland and promote their rehabilitation through establishment of local support groups, developing and implementing community knowledge exchange programmes, administering community outreach activities, developing a schools education programme, supporting communities to develop and manage tourism and recreational activities and develop appropriate infrastructure.

STAKEHOLDERS INTERACTION

28 June 2023
Tullamore, Ireland.

- 2 Policy and government
- 11 Soil and Other Advisors
- – Business
- 9 Research community
- 4 Farmer/land Owner
- 7 CSOs and NGOs

Relevant Soil Mission Objectives

- 2. Conserve soil organic carbon stocks
- 5. Prevent erosion
- 6. Improve soil structure to enhance soil biodiversity

Funded by the European Union

PREP SOIL

Regions SOIL Needs Assessment

Mixed

Reforestation

Authors

Karel Charvát (LESPROJEKT; charvat@lesprojekt.cz),
Jaroslav Šmejkal (LESPROJEKT; smejkal@lesprojekt.cz)

Scan the QR Code and visit the Workshop Page to access all the materials

Jihovychod (Czech Republic)

REGIONAL INFORMATION

The Vysočina "Highlands Region", of the Czech Republic, is located partly in the southeastern part of the historical region of Bohemia and partly in the southwest of the historical region of Moravia (https://www.kr-vysocina.cz/).

Dominant land use	Agriculture (61%)
Secondary land use	Woodland (30%)
Climatic Zone	Moderate Continental.
Soil WRB classification	Dystric Cambisol, Gleyic Luvisol.
Soil type	Medium
Dominant topsoil texture	Medium
Soil threat(s)	Erosion, Acidification
Representative for regions	Jihlava

SOIL NEEDS ASSESSMENT

Drivers

Climate change is a significant biophysical driver affecting agriculture. It involves changes in temperature, floods, droughts, and wind storms. Vysocina being a highland region, water erosion is recognized as a serious problem. **Bark Beetle Calamity** started in 2017, which was mainly influenced by large monocultures of spruce and partly influenced by climatic changes.

Pressures

The physical environment of Vysočina has witnessed notable shifts in recent years, mainly due to multifaceted pressures arising from biophysical and socioeconomic drivers. **Climate Change and Soil Management Practices; Erosion and Land Use; Socioeconomic Impacts and Soil Management Evolution.** For Vysočina, the future envisions a landscape where the pressures of 2050 are preemptively addressed.

State

The changes in the state of soils in the region changed from "healthy" towards "moderately healthy."
Biophysical Situation: Soil has transformed over the years; **Soil Organic Matter**: The prevalence of spruce monocultures, the impacts of the bark beetle calamity, have caused a decline in organic matter input; **Soil Erosion**: The region's susceptibility to water erosion has been exacerbated by climate change; **Soil Nutrient Retention**: The dominance of certain crops, often backed by subsidies, has impacted the soil's nutrient balance; **Soil Biodiversity**: Both crop composition in agriculture and forestry practices have implications for soil biodiversity.

Impact

The main impacts are: **Provision of Food, Fibre, and Biomass**: Impaired soil health negatively affects crop growth and productivity; **Water Purification and Soil Contaminant Reduction**: Reduced soil health hinder its natural ability to filter and purify water; **Water Flows Regulation**: Eroded soils with compromised structures may not efficiently regulate water flows, leading to increased flooding risks; **Drinking Water Resources**: Nutrient imbalances and potential leaching can risk contaminating drinking water sources; Carbon Storage and Climate Regulation: Decreased organic matter content can impact the soil's ability to store carbon; **Support for Biodiversity and Nature**: The shift towards monocultures and the impacts of erosion have had detrimental effects on soil biodiversity.

Response

Envisioning a sustainable Vysočina, stakeholders aim to cultivate a landscape characterized by thriving agriculture, sustainable forestry, and balanced ecosystems. By 2043, the region should be a beacon of innovation where traditional values merge with contemporary sustainable practices. Farmers and forest owners would employ cutting-edge techniques that bolster soil health while ensuring productivity. Policymakers would enact adaptable regulations that prioritize the environment and the local economy. Moreover, a collaborative spirit would be the region's hallmark, with knowledge-sharing and cooperative efforts at the core of all activities. The region aims to foster increased awareness, promote the adoption of sustainable soil management practices, and prioritize collaboration across sectors.

KEY MESSAGE

For an optimal soil health framework and a robust socio-economic fabric in Vysočina, a dedicated thrust on research and innovation is indispensable. The recent workshop threw light on pivotal areas like precision farming, Earth observation, and sensor measurements, intertwined with the enriching potential of citizen science. A novel concept discussed was the quantification of the allure of fields or forest sections, which holds the promise to revolutionize decision-making for farmers and forest proprietors.

STAKEHOLDERS INTERACTION

19 May 2023
Žďár nad Sázavou, The Czech Republic

- 3 Policy and government
- 2 Research community
- 9 Soil and Other Advisors
- - Farmer/land Owner
- 1 Business
- 2 CSOs and NGOs

Relevant Soil Mission Objectives

- 4. Reduce soil pollution and enhance restoration
- 5. Prevent erosion
- 6. Improve soil structure to enhance soil biodiversity

Urban-Industrial

Urban - Industrial

Post-Mining

Authors
Grzegorz Siebielec (gs@iung.pulawy.pl)
Karolina Świątek (kswiatek@iung.pulawy.pl)
Sylwia Siebielec (ssiebielec@iung.pulawy.pl)
Artur Łopatka (artur@iung.pulawy.pl)

Scan the QR Code and visit the Workshop Page to access all the materials

Slaskie (Poland)

REGIONAL INFORMATION

Upper Silesia is a region with mosaic of post-industrial sites and deposits, arable lands, hobby gardens, settlements. Part of the land has been contaminated with trace metals by smelter emissions

Dominant land use	Industry
Secondary land use	Urban/arable
Climatic Zone	IPCC - cool temperate moist
Soil WRB classification	Cambisols, luvisols, podzols
Soil type	Mineral, loamy soils
Dominant topsoil texture	Silt loam, sandy loam
Soil threat(s)	Contamination, soil sealing, land abandonment
Representative for regions	Post industrial areas in Eastern Europe

SOIL NEEDS ASSESSMENT

Drivers
Soil contamination from industries, waste management, and climate change is identified as the major factors affecting soil conditions in the region. There are still insufficient awareness of the ecosystem services provided by soils, especially in the urban environment of larger agglomerations. Legal regulations and financial mechanisms, such as EU strategies for soil protection and national funds, play a role in supporting soil regeneration efforts.

Pressures
The main pressures identified include urbanization, prolonged droughts, limited interest in soil management by local authorities, the absence of regulations on cultivating soils with increased contaminants and limited competence in urban greening practices. Climate change exacerbates these pressures by causing droughts, storms with intense rainfall, and snowless winters.

State
The main soil degradation process identified is the presence of pollutants in some areas.
Soil sealing has been intensive in agglomerations that were economically developing.
Wind erosion has intensified in urbanized areas. Overall biodiversity was recognised as low.

Impact
Current soil management in the region is not optimal. Agricultural production and hobby gardening on soils with elevated metals causes their transfer to crops. The current condition of soils supports cultural and landscape services but reduces carbon sequestration and water retention. Accelerated wind erosion induces air quality problems in urban areas.

Response
There needs to be focus on soil restoration. Experts recommend implementing initiatives and legislative changes to promote land reuse and increase in green areas in cities. The key changes required include better cooperation among stakeholders, raising public awareness, interdisciplinarity in spatial planning. Education of citizens and dissemination of scientific soil research is one of most important expected responses.

KEY MESSAGE

Soil Mission measures are of great importance to the region. This includes increasing soil literacy and co-creation processes or harmonized soil monitoring program. There is a need for more systematized, updated and available soil information. Research should also focus on: green and blue solutions in populated areas; soil regeneration; cycling of contaminants; microplastic pollution; transition in agriculture without hampering economic situation of farmers; combining spatial planning and soil management into one concept.

STAKEHOLDERS INTERACTION

23 June 2023,
Katowice, Poland

- 1 Policy and government
- 2 Soil and Other Advisors
- 3 Business
- 11 Research community
- 2 Farmer/land Owner
- 4 CSOs and NGOs

Relevant Soil Mission Objectives

- 3. Stop soil sealing and increase re-use of urban soils
- 4. Reduce soil pollution and enhance restoration
- 8. Improve soil literacy in society

PREP SOIL

Regions SOIL Needs Assessment

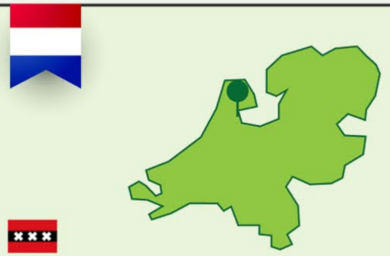
Urban - Industrial

Dense Urbanism

Authors

Laura Nougues (laura.nougues@deltares.nl) and Linda Maring (linda.maring@deltares.nl), Deltares

Scan the QR Code and visit the Workshop Page to access all the materials



Noord (The Netherlands)

REGIONAL INFORMATION

Amsterdam is the densely populated and built-up Capital of the Netherlands, built on soft soils. Both today and in the past, it has had a high urbanization rate due to the city's progressive industrialization and economic prosperity.

Dominant land use	Artificial land
Secondary land use	Grassland (21.0%)
Climatic Zone	• Artificial built-up area – (inner city, housing no garden, offices, schools) • Artificial industrial built-up area – (industrial area, harbour...) • Artificial non built-up area (sealed) (parking lots, infrastructures, roads, rails) • Urban brownfield (=land in transition to more beneficial use) • Road and railway berms • Private gardens with green potential (office gardens, housing) • Leisure (events, sport fields, playgrounds) • Urban agriculture • Agricultural area outside the city • Nature and recreational areas outside the city (incl water & peatland) • Subsurface space
Soil WRB classification	Gleysols and Histosols (but mainly technosols)
Soil type	Anthroposols, peat, sea clay
Dominant topsoil texture	NA (in many urban areas fill sand is used, in parks / gardens /etc garden soil can be applied)
Soil threat(s)	Sealing, contamination, loss of biodiversity, loss of organic matter (peat), land subsidence, soil degradation due to disturbance, compaction, and -in parts (external)- salinization (through Noordzeekanaal)
Representative for regions	Highly urbanized areas all over Europe. Especially in same climatic regions / delta areas (soft soils).

SOIL NEEDS ASSESSMENT

Drivers

Climate change is the main biophysical driver in Amsterdam. The average temperature in 2050 could be 1-2.3°C higher than the 1981-2010 average, and maximum summer temperatures are also expected to increase. Under the socioeconomic drivers in Amsterdam, urbanization and the digital & energy transition play an important role, as well as the positive, greening transition.

Pressures

The main physical pressures identified for Amsterdam are soil sealing, soil compaction and soil disruption including soil contamination, all largely caused by urbanization related activities. Further, the growing spatial pressure in the subsurface plays an important role, which is partly caused by urbanization but also by the digital & energy transition.

State

Amsterdam has a soft peat subsurface making it susceptible to damage to constructions and building foundations. Further, the chemical soil quality is poor in Amsterdam. For example, diffuse lead contamination and emerging contaminants such as PFAS. Lastly, the subsurface is literally full with assets such as cables, pipes and other underground structures and a lot of damage occurs every year when performing activities in the subsurface.

Impact

The main impacts are soil degradation and compaction, loss of biodiversity, a decreasing chemical soil quality, a decreasing water storage capacity and infrastructural damage caused by land subsidence, making soils less suitable for the urban land uses.

Response

Define urban soil health, where a distinction is made between specific urban land uses. Support the transition to urban soil health by clearly defined frameworks and policies. Build awareness and create a shared vision together with citizens, landowners and governments in which soil is presented as a valuable asset. Invest in urban LLs: they can increase knowledge and improve soil health.

KEY MESSAGE

Defining what soil health is and what it can bring to the different urban land uses is crucial. It is important to recognize the unique characteristics and requirements of urban soils which differ from the more homogenous agriculture, nature and forest soil ecosystems. In urban areas, an integrated approach, cocreated with relevant actors is necessary for dividing the limited space for the many demands and improving soil health. This includes multifunctional land use.

STAKEHOLDERS INTERACTION

20 April 2023,
Amsterdan, The Netherlands

- 11 Policy and government
- 2 Soil and Other Advisors
- – Business
- 8 Research community
- – Farmer/land Owner
- – CSOs and NGOs

Relevant Soil Mission Objectives

- 3. Stop soil sealing and increase re-use of urban soils
- 4. Reduce soil pollution and enhance restoration
- 6. Improve soil structure to enhance soil biodiversity
- 8. Improve soil literacy in society

PREP SOIL

Regions SOIL Needs Assessment

Urban - Industrial

Post-Mining

Authors

Blaž Repe (blaz.repe@ff.uni-lj.si),
Barbara Kostanjšek (barbara.kostanjsek@bf.uni-lj.si)
and Naja Marot (naja.marot@bf.uni-lj.si)
from the University of Ljubljana

Scan the QR Code and visit the Workshop Page to access all the materials

Vzhodna Slovenija (Slovenia)

REGIONAL INFORMATION

The Zasavje region is located in the central part of Slovenia, between the capital city of Ljubljana and Celje (the 3rd largest city). The region can be classified as a post-industrial region, more specifically, a post-mining region.

Dominant land use	Forest (67.5%)
Secondary land use	Grassland (21.0%)
Climatic Zone	Cfb, Temperate oceanic climate, without dry season and warm summer (Temperate continental, central Slovenia)
Soil WRB classification	Cambisols and Leptosols
Soil type	Cambisols: Eutric, Dytric or Chromic. Leptosols: Mollic, Rendzic or Dystric
Dominant topsoil texture	Different Loamy textures (loam, silt loam)
Soil threat(s)	1. Soil erosion 2. Soil contamination 3. Soil acidification 4. Urban sprawl and urbanization 5. Invasive organisms
Representative for regions	Post-mining region, Central European region

SOIL NEEDS ASSESSMENT

Drivers

The most important biophysical drivers are the parent material and topography, water erosion and vegetation cover (protects against erosion processes). Further the (lack of) national and local politics is an important socioeconomic driver as well as the mining activity and accompanying industry.

Pressures

The five most pronounced pressures are: 1) soil erosion and other negative slope processes (landslides), 2) soil and water contamination, 3) soil acidification (induced by past Trbovlje thermal power plant acid exhausts), 4) urban sprawl and industrialization and 5) invasive organisms.

State

The region is characterised by two types of landscapes: the mountainous part and the valley part. The state of the mountainous part is largely affected by natural factors (steep and rugged topography, hard and consolidated rocks, rapid runoff of precipitation water and watercourses), while the state of the soil in the valley largely reflects human activities (flat topography, softer and unconsolidated rocks, industrialized area).

Impact

In the mountainous part, the steep and rugged topography makes the soil less stable and shallow and, in combination with heavy rainfall, the soil is subject to landslides. In the valley, the past industrial long term pollution results in excessive concentration of heavy metals in soils, plants and water. Further, underground mining and surface extraction of rock material lead to soil subsidence.

Response

Regarding the policy sector, adequate soil legislation should be adopted at EU level, but municipalities should also manage space strategically through multi-year programmes. Further, a clear soil monitoring program should be established and performed yearly. Lastly soil health awareness should be raised at all levels: municipal officials, higher education, primary education etc.

KEY MESSAGE

There is a lack of knowledge about soil and soil management. Therefore, it is essential to establish a monitoring program, especially in severely degraded areas, to understand the scope of the problem and to inform the population on an annual basis. Then, stricter criteria on soil management need to be formed, especially on pollution, and more participation and networking of stakeholders (farmers, decision-makers) is needed.

STAKEHOLDERS INTERACTION

17th of May 2023,
Zasavje, Slovenia

- 10 Policy and government
- 1 Soil and Other Advisors
- – Business
- – Research community
- 1 Farmer/land Owner
- – CSOs and NGOs

Relevant Soil Mission Objectives

- 3. Stop soil sealing and increase re-use of urban soils
- 4. Reduce soil pollution and enhance restoration
- 5. Prevent erosion

Funded by the European Union

Forestry

Regions SOIL Needs Assessment

Forestry

Forest North

Authors
Sabine Jordan & Jennie Barron
(Swedish University of Agricultural Sciences, SLU; sabine.jordan@slu.se, jennie.barron@slu.se)

Scan the QR Code and visit the Workshop Page to access all the materials

Upper Noorland (Sweden)

REGIONAL INFORMATION

The challenges within the typical boreal forest catchment area Krycklan are to maintain natural soil ecosystem services in combination with sustainable forest management.

Dominant land use	Forest (87 %): Scots pine (Pinus sylvestris L., 63 %), Norway spruce (Picea abies (L.) H. Karst., 26 %) mixed with deciduous trees (Betula spp., Alnus incana (L.) Moench., and Populus tremula L., 11 %)
Secondary land use	Mires (9 %), lakes (1 %), agricultural lands (2 %), and rock outcrops (1 %)
Climatic Zone	Subarctic with a 30-year (1991–2020) mean annual precipitation of 638 ± 40 mm and a mean annual air temperature of 2.4 ± 0.3°C
Soil WRB classification	Podsols, Regosols, Histosols, Gleysols, Leptosols and Arenosols
Soil type	Poor mineral soils (mostly podsols) and peatlands
Dominant topsoil texture	Silt, sand, fibric and decomposed peat
Soil threat(s)	Climate change: Droughts and extreme weather, bark beetle outbreaks, browning of freshwater Forestry operations: Soil damage and compaction; ditching affecting soil health, water quality, carbon sequestration and storage below and above ground, and biodiversity
Representative for regions	Fennoscandia, Canada, Baltics

SOIL NEEDS ASSESSMENT

Drivers
Climate change with higher temperatures and extreme weather can affect browning of freshwater, outbreaks of bark beetle, forest fires and natural forest carbon pools above and below ground. Industrial forestry can lead to soil damage resulting in decreased biodiversity and carbon sequestration in drained peatlands while increasing the timber production.

Pressures
Forest conversion with replacement of coniferous monostands would be a desired pressure. This may result in financial penalties for the forest owners. Rewetting of drained peatlands as a climate-smart mitigating measure can release toxic metals and phosphorus and offsets the environmental objective of 'zero eutrophication'.

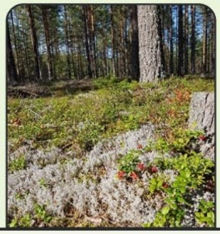
State
High-latitude regions have the largest standing soil carbon stocks and are sensitive to warming and change in soil moisture regimes inducing carbon losses. Reduced forest rotation time and increased forest density stimulate productivity. Fire-fighting systems are highly developed and forest fires are no problem. New ditching is forbidden (maintenance only), affecting forest productivity.

Impact
Climate and forestry directly impact e.g. the soil's climate regulation by carbon sequestration, the provision of food, fibre and biomass for energy and material production, the support for biodiversity and nature. They are coupled to each other and must be taken into consideration together when judging over a single one.

Response
Private and governmental forest organisations waking people's awareness for the sustainable use of our soils through informative material (e.g. short movies, maps, flyers, seminars). This will lead to an enhanced soil literacy.

KEY MESSAGE

How do we manage our productive forests soil-smart? Forestry on nutrient-poor soils and on rocky morainic material is without concurrence to any other land uses. The long-term issue of securing water and carbon storage in soils (and above ground) and to reduce potential negative impacts such as soil damage need more responsive forest management strategies.



STAKEHOLDERS INTERACTION

May 29th 2023,
(SLU) in Uppsala (Sweden)

- 4 Policy and government
- 4 Soil and Other Advisors
- – Business
- 9 Research community
- 3 Farmer/land Owner
- 1 CSOs and NGOs

Relevant Soil Mission Objectives

- 2. Conserve soil organic carbon stocks
- 4. Reduce soil pollution and enhance restoration

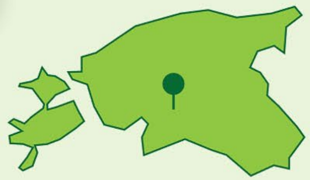
Funded by the European Union

Forestry

Forest Peatland Northeast

Authors
Anna-Helena Purre
(Elige OÜ; anna.helena.purre@elige.ee)
and Sabine Jordan
(Swedish University of Agricultural Sciences; sabine.jordan@slu.se)

Scan the QR Code and visit the Workshop Page to access all the materials



Soomaa, Estonia

REGIONAL INFORMATION

Soomaa is characterized by low population, wilderness and tourism. The dominating land-uses in the area are pristine bogs, forestry on peatlands, and semi-natural meadows.

Dominant land use	Forestry on fens and transitional peatlands, and on the edges of the bogs
Secondary land use	Nature protection (bog area with pools, forest habitats, semi-natural meadows, and birds)
Climatic Zone	Temperate
Soil WRB classification	Mainly Histosols: bogs in natural state but also heavily drained fen peat and transitional peat
Soil type	Histosols, Gleysols, Fluvisols, Histic gleysols, Gleyic albeluvisols
Dominant topsoil texture	Highly decomposed peat
Soil threat(s)	Peatland drainage for forestry; tracks from harvesters
Representative for regions	Forestry on peat soils mainly in Scandinavia and Baltic states (Northern Europe).

SOIL NEEDS ASSESSMENT

Drivers
The main biophysical driver in the region has been the **periodic spring flooding** related to snowmelt ("fifth season"). With climate change, in addition to the spring flooding also **winter flooding or the "sixth season"** has occurred during the recent years, but also **warmer summers with extreme drought periods**.

Pressures
Wet peatland soils and their management with heavy machinery. This is also related with very short forest management periods, planting of spruce and pine **monocultures**, and **restoration of peatlands and semi-natural habitats** on former forest land.

State
The state of the soils is generally **good inside of the protected areas** whereas it is expected to be lower outside of it. The soil state is affected mainly by drainage of peat soils (incl. reconstruction of ditches) and management with heavy machinery during times when the soil is unfrozen.

Impact
The area is important for **water buffering, carbon accumulation, and recreation**. The drainage systems reduce the water retention time after the floodings but also drain the peat soils leading to carbon release from the soil layer and increase in wood production. With drainage, open bog landscapes are replaced with forests.

Response
The stakeholders had following **visions for the Soomaa area**: wilderness area, balanced and homogenous development, forest management for own use of farmers and stricter approach to forest management, natural succession, improvement of tourist infrastructure, increase the area of the national park and less drastic differences between the national park and outside areas.

KEY MESSAGE

Soomaa is an area with low number of inhabitants and regular floodings. Although the Soomaa area has been managed, these actions and their results are mainly not monitored. In addition, the impact of tourism in Soomaa has not been studied in detail so far.

STAKEHOLDERS INTERACTION

3rd May 2023,
Soomaa National Park

- 2 Policy and government
- 1 Soil and Other Advisors
- – Business
- 3 Research community
- 6 Farmer/land Owner
- 8 CSOs and NGOs

Relevant Soil Mission Objectives

- 2. Conserve soil organic carbon stocks
- 6. Improve soil structure to enhance soil biodiversity

PREP SOIL

Regions SOIL Needs Assessment

Forestry

Forest Tourism South East

Authors
Prof. Ertuğrul BİLGİLİ[1], Prof. Turgay DİNDAROĞLU[1], Prof. Tuğrul YAKUPOĞLU[2], Assoc. Prof. Uzay KARAHALİL[1] – [1]Karadeniz Technical University, Faculty of Forestry, 61080, Trabzon, Türkiye – [2]YozgatBozok University, Faculty of Agriculture, Yozgat, Türkiye

Scan the QR Code and visit the Workshop Page to access all the materials

Antalya (Turkey)

REGIONAL INFORMATION

Köprülü Canyon NP, located in Antalya, has various forests, cultural areas and ecotourism activities. However, forest fires and climate change pose risks to soil health.

Dominant land use	Protected area, Extensive Tourism & Recreation
Secondary land use	Forestry, Semi natural areas, Agriculture (Rural)
Climatic Zone	Mediterranean climate (Csa) with hot and dry summers
Soil WRB classification	1-Order: Entisol, Sub-order: Orthent 2-Order: Alfisol, Sub-order: Xeralfs 3-Order: Inceptisol, Sub-order: Xerepts
Soil type	Terra Rosa
Dominant topsoil texture	ClayLoam
Soil threat(s)	water erosion, organic matter decline, desertification
Representative for regions	Mediterranean Europe forest regions with tourism, fringing agriculture and are susceptible for wild fires: Spain, Portugal, southern France, Italy, Greece, coastal parts of Balkan and Israel.

SOIL NEEDS ASSESSMENT

Drivers
Climate change, soil fertility, and wildfires are the main biophysical drivers in Köprülü Canyon National Park. These drivers are expected to continue impacting the region in the future, affecting agriculture, tourism, and overall livelihoods. Collaboration is needed for sustainable solutions.

Pressures
The intertwining of residential, forest, protected, and tourism areas creates management problems. Reduced water availability and quality due to climate change and water misuse impact agriculture and tourism. Forest fragmentation increases disease occurrence. Tourism activities and expanded road networks negatively effect soil health.

State
Soil fertility and water availability have decreased in Köprülü Canyon NP, leading to suboptimal crop yields. Reliance on artificial fertilizers has increased, causing nutrient run-off and affecting ecosystems and human health in the region. The porous rock composition of the area further complicates water management.

Impact
Tourism activities in Köprülü Canyon National Park negatively affect soil functions by causing soil erosion and fragmentation of forests. Farmers are aware of the importance of healthy soil, but economic constraints affect land use changes. The decrease in soil functions has increased the risk of disease on forest tree species.

Response
Collaboration among stakeholders is crucial for sustainable forest and soil management. Policy changes and incentives can encourage conservation efforts. Public awareness of healthy soil and organic fertilizers in tourism development is important. Adaptation strategies and monitoring systems are needed to manage changing environmental conditions.

KEY MESSAGE

Stakeholders must establish a shared vision for sustainable forest and soil management. Eco-tourism can increase livelihoods, but technology and infrastructure impact tourism. The strict protection status of the national park may need to be modified. Organic fertilizers should be promoted, and climate change impact studies conducted.

STAKEHOLDERS INTERACTION

26 April 2023,
Antalia, Turkey

- 9 Policy and government
- – Soil and Other Advisors
- – Business
- 14 Research community
- 25 Farmer/land Owner
- 1 CSOs and NGOs

Relevant Soil Mission Objectives

1. Reduce desertification
2. Conserve soil organic carbon stocks
5. Prevent erosion
7. Reduce the EU global footprint on soils

Funded by the European Union

Join the Community

prepsoil.eu

@prepsoil

/company/prepsoil

@prepsoil

zenodo PREPSOIL

PREP SOIL

Regions SOIL Needs Assessment

Funded by the European Union