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Exploring participatory approaches to soil health knowledge co-production in agroecological network

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THESIS APPROVAL

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I, ALESSIO SURIAN as supervisor of the student INÉS JIN ELVIRA PÉREZ, hereby APPROVE the thesis entitled "Exploring participatory approaches to soil health knowledge co-production in agroecological network".

Padova, 7TH SEPTEMBER, 2023

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International Master's Degree in Sustainable Territorial Development:
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Master Thesis

"Exploring participatory approaches to soil health knowledge co-production in agroecological network"

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Abstract

The thesis explores the importance of knowledge co-production practices in agroecological networks and their potential contributions to soil health regeneration. The research focuses on three case studies: *Rete Humus*, an Italian agroecological network; *Navdanya*, a women farmers and earth-centric NGO in India; and the *Soil Living Labs* and *Soil Lighthouses EU Soil Mission* implementation in Europe. The research brings insights into two main questions: What participatory approaches exist to soil health knowledge co-production? What are the elements of soil health knowledge co-production processes? The thesis investigates, for each case study, the research aims and methodologies, problem framings and contributing knowledge holders, as well as the approach to participation. It also analyses the knowledge creation process and the outputs, outcomes, and the usability of the produced knowledge to provide a nuanced understanding of their potential contributions to the health of the soil. The results highlight the importance of participatory practices to soil health knowledge co-production based on diverse types of knowledge and farmer-centric approaches that create emancipatory processes enabling the transition to more just and ecological food systems. Additionally, the research reveals how participatory tools can serve as communication strategies for biodiversity and soil health, sparking the adoption of agroecology and soil regeneration. Overall, knowledge co-creation in agroecology offers a promising approach to addressing the complex challenges of transforming food systems and healing our soils.

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Glossary

EU: European Union
SLL: Soil Living Labs
LHs: Light Houses
CAP: Common Agricultural Policy
SOC: Soil organic carbon. "Soils contain carbon in organic and inorganic forms. The majority of carbon in most soils is stored as soil organic carbon in the form of soil organic matter, composed of decaying plant, animal, fungal and bacterial matter (Scharlemann et al., 2014, p.82)".

Chapter 1. Introduction

The survival, prosperity and security of our civilization depends upon a living soil. The soil is a living organism; in fact, a handful of soil contains more living creatures than there are humans on the planet (Veerman, 2023). Healthy soils are determined by conditions in which living organisms such as fungi, bacteria and worms can thrive (Veerman, 2023). Soil health is actually essential to the life of planet Earth, as 95% of our food grows in the soil (FAO, 2023). Soil also provides many other ecosystem functions such as the nutrients and physical structures enabling plant growth and biodiversity; retaining and purifying the water we drink, regulating flooding and acting as a buffer against pollution and soil erosion (Head et al., 2020). Furthermore, soils capture carbon from the atmosphere and store it in the ground, thus, becoming a carbon sink and tackling climate change (Lal, 2004; Scharlemann et al., 2014). While uncertainty exists around soil organic carbon (SOC) estimations, soils and surface litter contain at least two to three times as much carbon as is stored in vegetation and the atmosphere (Scharlemann et al., 2014).

However more than 30% of our soils globally are classified as unhealthy (FAO, 2023) and that figure elevates to ~60-70% in Europe (Veerman et al., 2020). The intensification of industrial farming after the “green revolution”[1] has led to the transgression of several planetary boundaries, as well as depleting natural resources to the degree of degrading life support systems and widening inequalities (Campbell et al., 2017). Industrial agriculture led to the outsourcing of knowledge, technologies and resources such as energy, water or labour (among others), contributing to the degradation of natural and human ecosystems (IPES food and ETC Group, 2021). The need to reverse these processes calls for the reintegration of these elements back into food systems.

To address this, it is increasingly recognised that more sustainable and applicable outcomes occur when agricultural knowledge is co-produced as opposed to transferred through a top-down mechanism (Utter et al., 2021). While more hierarchical structures have often shaped industrial agricultural research, less hierarchical knowledge structures have emerged within the emerging field of agroecology which aims to achieve a transdisciplinary approach of pursuing epistemically inclusive science (Warner, 2008; Cuellar-Padilla and Calle-Collado, 2011; Kelinsky-Jones, 2022).

These participatory approaches to soil health knowledge co-production processes can enable more socially and ecologically robust knowledge, which is more suitable for situations with more complex interactions, characteristic of wicked problems, participatory and farmer-centred processes and outcomes in agroecology (cf. Rosset & Altieri, 2017; Méndez & Morris, 2021). Knowledge co-production can also improve soil governance processes

[1] The term “green revolution” refers to a bundle of *modern* industrial agriculture technologies (eg. hybrid seeds, chemical fertilisers) which were *exported* from the United States to the global south countries, in the decades of the 60s and 70s, leaving important negative consequences in terms of the exacerbation of inequalities and loss of ecosystem productive capacity (Patel 2013).

(Prager & McKee, 2015), as well as the emergence of interdisciplinary (combining several disciplines) and transdisciplinary (going beyond disciplines) collaborations with diverse societal stakeholders. It can also advance food system transformation sustainability and equitably through the prioritisation of epistemic inclusion (Kelinsky-Jones, 2022). Epistemic inclusion refers to the practice of "knowledge/wisdom dialogues" or "diálogos de saberes", inclusion of diverse types of knowledge such as indigenous, local and ancestral to name a few. The inclusion of indigenous and local knowledge systems is essential to the transformation of food systems towards more socially just and ecologically sound food systems (Carolan, 2006; Warner, 2006; Cuéllar-Padilla and Calle-Collado, 2011; Méndez et al., 2013; Vandermeer and Perfecto, 2013; Méndez et al., 2017; Heleba et al., 2016; Utter et al., 2021). When farmers engage in co-production of knowledge they are identified as innovators who inspire and lead bottom-up transitions within their communities (Chambers and Ghildyal, 1985; Utter et al., 2021), thus creating a basis for a more inclusive research approach (Kindon et al., 2007).

The understanding and usage of the term "knowledge co-production", which is here used interchangeably with "knowledge co-creation", is not always clear and has often been misused (Utter et al., 2021). I use the term "knowledge" in its broader configuration, including data, information and wisdom, while there can be differences among the terms based on their acquisition processes and contextualization (Jasanoff, 2004; Utter et al., 2021). Knowledge co-production can be understood as "a collaborative process involving two or more actors who are intentionally integrating their knowledge and learning, resulting in the development of insights and solutions that would not otherwise be reached independently" (Utter et al., 2021, p. 1). This goes beyond "passive merging, incorporating and/or exchanging different knowledge, ranging from scientific data to cultural understanding" (Utter et al., 2021, p. 1).

This can lead to the dialogue of different types of knowledge, and thus co-producing knowledge. It is important to ensure that in this process, this local knowledge is not re-branded as something new, and that the discovery of existing knowledge and wisdom acknowledges its origins, in a way that is respectful and has obtained the consent for sharing (Utter et al., 2021). Especially in the context of agriculture, farmers are actively researching and experimenting in the field to improve agricultural practices and outcomes (Milgroom et al., 2016). This thesis explores how participatory soil health knowledge co-production processes can enable the agroecological transition towards more ecological and socially just food systems and contribute to the healing and regeneration of soils.

This thesis explores three elements - settings, synthesis and diffusion - which characterise participatory soil health knowledge co-production processes in agroecological networks (Malmborg et al., 2022). The dimension "settings" looks into the research aims and methodologies, problem framing and contributing knowledge holders of the knowledge co-production process, "synthesis" analyses the process and "diffusion" looks into the knowledge outputs, outcomes and their usability (Malmborg et al., 2022). To carry out this research, I analyse three case studies located in India, Italy, and the European Union. The timeframe of research starts with the creation of the case studies until August 2023, offering a comprehensive perspective on the elements conforming to the processes of knowledge co-production evolution elements evolution of participatory approaches. While the benefits of knowledge co-production have been somewhat researched (Meadow et al., 2015) the processes of knowledge co-production remain less understood (Utter et al., 2021) and especially in the context of agroecology and soil health.

The overarching goal of this thesis is to explore the various participatory approaches used in the co-production of soil health knowledge within agroecological networks. To achieve this goal, the thesis seeks to address two central research questions:

1. What participatory approaches exist to soil health knowledge co-production in agroecological networks?
2. What are the elements (settings, synthesis and diffusion) of the soil health knowledge co-production processes within these agroecological networks?

The study employs a qualitative research design, applying a comparative case study analysis to explore the participatory approaches and co-production elements within the selected agroecological networks and other soil-relevant knowledge co-creation initiatives. Through semi-structured interviews, data collection and thematic analysis, the research aims to provide a nuanced understanding of how participatory tools are employed, the challenges faced, and the potential for transformative change.

This chapter sets the stage for the exploration of participatory knowledge co-production soil health knowledge in agroecological networks. The interconnectedness of soil health, participatory approaches, and Indigenous knowledge within the context of a significant degradation of the soil globally emphasises the significance of this research. As the thesis unfolds, subsequent chapters will first review the literature on knowledge co-production in agroecology, situating it in a broader context of emerging participatory research approaches in soil health knowledge co-production I then present the analytical framework through which the following results section will analyse the case studies featuring various soil health knowledge co-production processes. Each case study is rooted in different settings and scales, the common denominator is however, the commitment to collaborate with various stakeholders to co-produce knowledge around soil health to achieve the regeneration of the soil and contribute to the agroecological transition food systems transformation. In each case, the knowledge co-production process is presented based on an analysis of several data sources: interviews, field notes and desk research. From these cases, I draw insights from research conducted in the context of soil health and the agroecological paradigm. The thesis concludes approaches, co-production elements, and their implications for sustainable soil health knowledge co-production within diverse agroecological networks.

Chapter 2. Literature Review

This chapter provides a literature review on participatory soil health knowledge co-production in agroecological networks. This literature review aims to provide an overview of the state of the art in terms of the main conceptual domains: “soil health”, “agroecology” and “agroecological transition”, “knowledge co-production”, . There was no limitation by year in the search, to ensure both recent and seminal works were considered. A combination of academic databases and grey literature was consulted to ensure a comprehensive review of the relevant literature. Databases included *Web of Science, Scopus, and Google Scholar* were also explored. In addition to academic sources, grey literature from international organisations, government agencies, and NGOs were considered to capture a diverse range of perspectives.

Soil health

Soil health is essential to sustain life on Earth, but two thirds of soils in Europe are in bad condition (ECA, 2023) and more than 30% globally (FAO, 2023). Healthy soils strengthen resilience to natural disasters, mitigate and adapt to climate change, revert biodiversity loss and desertification (FAO, 2023). The regeneration of soil health is indeed a wicked sustainability problem embedded in the challenge of transforming/transitioning our food system towards a more just and ecological system.

Figure 2.1. Overview of the sustainable development goals linked to soil. Source: European Court of Auditors (2023).

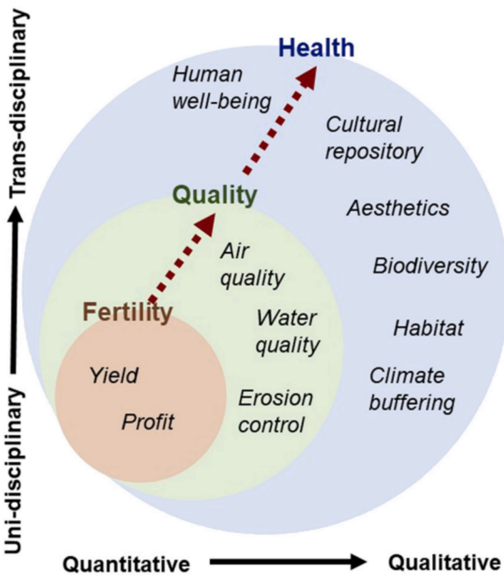
As Figure 2.1. shows, at the global level, the UN Sustainable Development Goals are directly and indirectly dependent on living soils to achieve the goals such as zero hunger (SDG 2), healthy lives (SDG 3), clean water (SDG 6), climate action (SDG 13), sustainable consumption and production (SDG 12) and life on land (SDG 15) (European Court of Auditors, 2023).

Soil health

This section captures the debates around the definition of soil health. "Soil health" is a concept that remains ambiguous in the literature. As Figure 2.1 shows, several concepts have been used to address soil health, such as fertility or quality, these terms have often been used interchangeably, thus, the boundaries are not always distinct and operational procedures are being developed (Bonfante, Basile and Bouma, 2020).

However, this conceptualization and nuance of these terms can be a useful approach to better understand them. The figure creates boundaries between the concepts distinguishing between its quantitative and qualitative assessment as well as the level of transdisciplinarity required for its study.

Figure 2.1. Soil concepts and range of ecosystem functions considered.



Note: Janzen et al., (2021).

In this research I have followed the definition by Janzen et al. (2021), "soil health is the vitality[2] of a soil in sustaining[3] the socio-ecological functions[4] of its enfolding land[5]." This definition acknowledges not only the composition of soil, but also the functions of the land and its ecosystems in a particular place and time. Pursuing soil health goes beyond capturing numerically the "goodness of soil", and tries to generate understanding of the relational mechanisms that nurture attributes of soil which catalyse valued functions in the present and future.

There is not an overarching operationalization of the definition of a healthy soil as soil health is context specific and must be placed within a dynamic, location-specific feedback system taking into account biophysical, economic, social and political elements (Bennett et al., 2010; Bouma and McBratney, 2013) and therefore, the properties conferring health to the soil vary from place to place, thus the importance of local knowledge (Ng and Zhang, 2019). Furthermore, soil health entails a value judgement, thus requiring societal engagement in the definition of which kind of soil we want, (Clark, 1989), which is hard to reflect through the scientific measurements alone. Figure 2.2. Shows a diagram in which soil health perspectives are inferred from soil measurements (indicators) and projected through lenses of land functions and societal values, the elements within each section are examples and do not aim to be comprehensive.

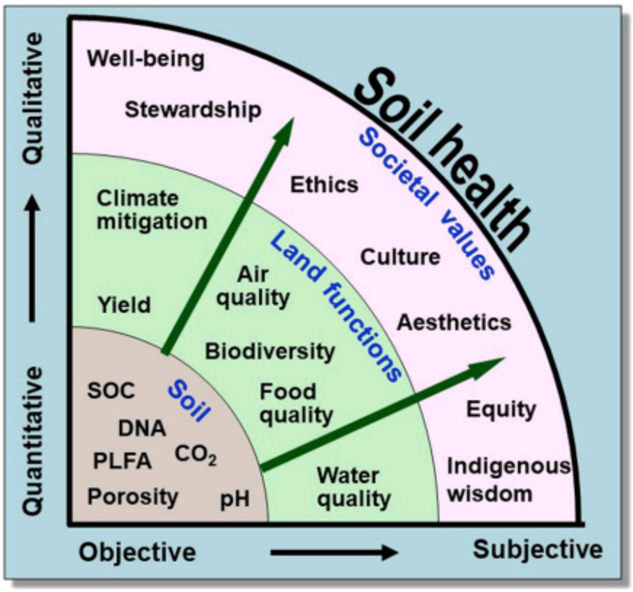
[2]"The soil is a living system composed of many interconnected processes mediated by thousands of organisms, many of them nameless biota (Jazen et al., 2021, p. 2)".

[3]"Soil health is not a climatic state or ever fully achieved, soil health depends on its capability to sustain the relevant functions of its ecosystem despite ongoing stresses and upheavals, thus it is connected to resilience (Jazen et al., 2021, p. 2)"..

[4] "The functions soil performs is to promote utility, not just "services" which usually imply direct human benefit, but also processes maintaining the integrity and stability of the biosphere. Soil's functions are dynamic and describe performance and behaviour. Health can be understood or evaluated and not just measured by the composition of soil, but by observing how well its ecosystem thrives (Janzen et al., 2021, p. 2)".

[5] Synonym to ecosystems (Janzen et al., 2021, p. 2).

Figure 2.2. Soil health perspectives are inferred from soil measurements (indicators) and projected through lenses of land functions and societal values.



Note: Janzen et al., (2021).

Soils are living environments that host an abundance of diverse microbiomes and fauna. Biological functioning has direct impacts on soil health, and therefore, plant growth and ecosystem health (Lemanceau et al., 2015). Practices that value land stewardship and conservation of agrobiodiversity such as those involving agroecology show higher metabolic efficiency in comparison to conventional systems (Chavarria et al., 2018). Bringing biodiversity back to food systems and the soil is one of the principal strategies agroecology proposes to induce self regulation and achieve sustainable balances in the food agroecosystem. Agroecology is based on resilient, energetically efficient, biodiverse, socially just food systems, providing ground for emancipatory strategies on food, energy and seeds (Altieri et al., 2012).

Conventional agriculture is often based in transgenic crops developed for pest control using agrochemicals, which have frequently failed to control insect pests, pathogens and weeds, accelerating the evolution of resistant plagues (Altieri and Nicholls, 2000; Tabashnik and Carrière, 2017). More importantly, cultural methods such as crop fertilisation can affect the susceptibility of plants to insect pests by altering plant tissue nutrient levels. Research has shown that optimal physical, chemical and mostly biological properties of the soil determine the ability of a crop plant to resist or tolerate insect pests and diseases (Altieri and Nicholls, 2003). This reflects the need for alternative food systems.

These types of problems require new approaches which are more participatory, interand transdisciplinary, as well as inclusive of different types of knowledge such as local, indigenous and ancestral knowledge. In this context, agroecology has often emerged as the exemplary example of such an approach. The agroecological transition in our food systems has emerged as an alternative or various alternatives to the current dominant industrial agrifood system which has been pinpointed as a major driver in the loss of soil health.

Agroecology and agroecology transition

The definition of agroecology has evolved from its framing in the 1980s focused on ecological science in sustainable agriculture to the more recent definition of agroecology as a science, practice and movement (Wezel et al., 2009). As a science and practice, agroecology advocates for the use of diverse techniques that protect and respect local ecosystems, biodiversity and fosters the biodiversity in our food systems (Holt-Giménez, 2002; Bergquist et al., 2012; Simon et al., 2017).

These practices, while reducing dependence on external inputs, increase the resilience to climate change and environmental degradation, contributing to the development of sustainable livelihoods by restoring ecosystems and improving ecological services in agroecosystems (Lanka et al., 2017; Simon et al., 2017). Traditional farmers have used these practices for centuries, creating diverse and locally adapted agricultural systems which often result in community food security and the conservation of agrobiodiversity, minimising risks, promoting diverse and nutritious diets and maximising returns by using low levels of technology and limited resources (Nicholls et al., 2004).

At the heart of agroecology there are knowledge co-production processes giving way to the transformation of our food systems through its redesign first at the level of agroecosystems and later with the society at large, by becoming part of social movements through education and collective action (Lopez-Garcia et al., 2021). In this way, farmers realise their influence in the food systems and develop agency to make decisions in the food system, thus, empowering small-scale farmers to have collective action and gain agroecology empowers farmers by realising their influence in the food system (Giraldo and Rosset, 2023). Agroecology's approach differs to that from conventional agriculture and "technocratic farming" focused on food commoditization, and draws attention to structural problems in agriculture such as input substitution, crop-livestock specialisation, agrarian class conflicts, gender inequality or democratic processes (Lopez-Garcia et al., 2021; Giraldo and Rosset, 2023).

The agroecological transition aims to restructure socioeconomic and political aspects in food systems to achieve a healthy, human-rights-based, and democratic decision-making process, thus enabling food sovereignty (Anderson et al., 2022). Gliessman (2016), puts forward a framework to classify the "levels" of food system change which can serve as a roadmap for global food systems transformation:

1. Level 1: Increase the efficiency of industrial and conventional practices in order to reduce the use and consumption of costly, scarce or environmentally damaging inputs.
2. Level 2: Substitute alternative practices for industrial/conventional inputs and practices.

3. Level 3: Redesign the agroecosystem so that it functions on the basis of a new set of ecological processes.
4. Level 4: Re-establish a more direct connection between those who grow our food and those who consume it.
5. Level 5. On the foundation created by the sustainable farm-scale agroecosystems achieved at Level 3, and the new relationships of sustainability of Level 4, build a new global food system, based on equity, participation, democracy and justice, that is not only sustainable but helps restore and protect earth's life support systems upon which we all depend.

Knowledge co-production in agroecology

The literature on knowledge co-production in agroecology has engaged in several case studies on participatory methods which often frame agroecology as a set of practices and as a movement within the social sciences, whereas the life/natural sciences focus more on the science and set of practices frame (Sachet et al., 2021, p. 7). Other participatory methods include participatory rural appraisal, rapid rural appraisal, participatory learning and participatory action research (PAR) which often look into the topic of the agroecological transition (Sachet et al., 2021, p. 7).

Transformative knowledge co-production is linked to collective action and decision-making in ecosystem management by and for the communities (Holt-Giménez, 2002; Apgar et al., 2017). This means that researchers become part of a specific socio-historical context; consequently, the research design must be reflexive and also transdisciplinary, going beyond academics, therefore, it must include non-academics (Lopez-Garcia et al., 2021).

I argue here that agroecological networks have a unique approach to understanding the problems that soil health challenges bring and put forward distinct solutions that have the potential to be more impactful. This requires a deeper investigation into the different elements of the knowledge co-production processes. The agroecological transition requires different pedagogical approaches to learning and knowledge co-production in agriculture. This is because agroecology goes beyond the promotion of new technologies or practices, but rather, promotes "transformative agroecology learning based on horizontalism; diálogo de saberes (wisdom dialogues); combining practical and political knowledge; and building social movement networks" (Anderson et al., 2022; Martínez-Torres and Rosset, 2017). The current literature has not looked into the knowledge co-creation processes for soil health knowledge co-creation in agroecological networks, thus this thesis will contribute to filling this gap by exploring three case studies related to soil health, two within agro ecological networks and one within an emerging soil network.

Chapter 3. Analytical framework: the knowledge co-production process

This chapter provides the lenses upon which subsequent research is built. It covers existing literature on knowledge co-production and develops on the elements that conform the process. Through this analytical framework, the research questions are addressed by providing the frame for the case studies. In order to compare knowledge co-production processes, I have followed the analytical framework used by Malmborg et al., 2022 which is summarised in this section. This analytical framework allows the identification of tensions and insights into the design of knowledge co-production processes and inform future research aiming to co-produce usable knowledge to contribute to soil health.

Knowledge co-production can be understood as an 'Iterative and collaborative process involving diverse types of expertise, knowledge and actors to produce context-specific knowledge and pathways towards a sustainable future.' (Norström et al., 2020). The study of this process in depth in the agroecological context is chosen, as agroecology has often been described as an ideal context enabling high quality farmer participation in research. In fact, a central tenet of agroecology is the co-creation and sharing of knowledge (FAO, 2023), as well as valuing "all forms of knowledge and experience in food systems change" (Gliessman, 2018).

Agroecological knowledge research has mostly explored specific practices and principles (Maughan and Anderson, 2023; Altieri, 2016; Richardson et al., 2021), as it reflects its "emergent and counter-hegemonic status", low rates of funding and the mainstream politics of knowledge together with the lock-in of the agro-industrial food system (Maughan and Anderson, 2023). This calls to look into these processes in the context of soil health and agroecology. It is important to note that agroecology aims to improve agricultural science, but also actively contests and aims to transform the dominant knowledge regime, a challenge which may take decades or centuries to overturn (Levidow et al., 2014).

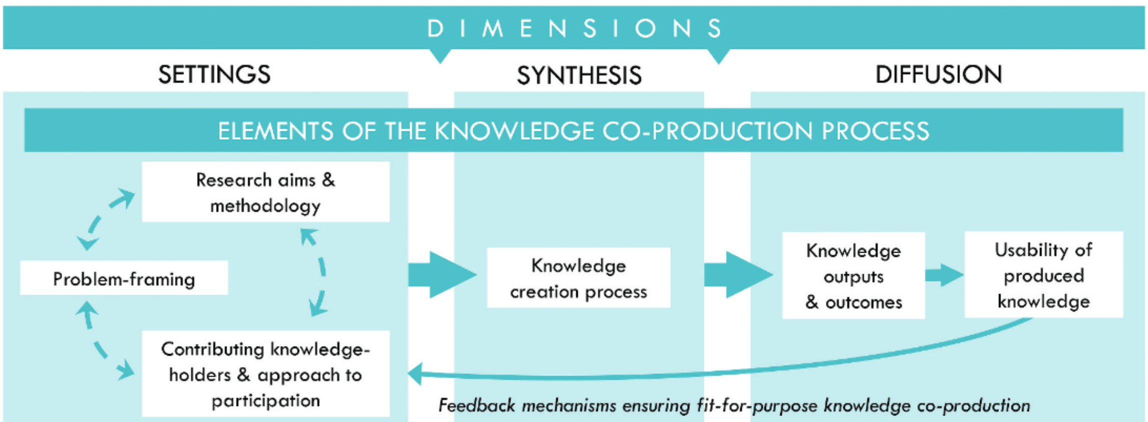


Figure 1. Analytical framework for comparing knowledge co-production processes from Malborg et al., 2022.

1. **First dimension: settings**

This dimension covers three overlapping elements. First research aims and methodologies including the explicit research aims for the project, theory, approach or methodologies guiding the design and tools. The aims that drive co-production efforts strongly shape them (Lövbrand, 2011; van der Hel, 2016). These can be quite diverse, ranging from trying to solve predefined problems by filling knowledge gaps to reframing problems to spark more diverse and innovative possibilities (Chambers et al., 2021).

Second, the Contributing knowledge-holders and approach to participation refers to the categories of knowledge-holders, for instance, actors with academic, practical and local knowledge (Tengö et al., 2014) and the motivation to invite them. This has implications in terms of the power relations that are reflected in which participants engage with the process. For instance, the process can focus on empowering marginalised actors such as grassroot groups or local officials or rather focus on influencing powerful actors such as international policy makers or corporations to yield power (Chambers et al., 2021).

The levels of engagement range from communication and consultation to deliberation and co-production (Reed et al. 2018). To further distinguish between types of contribution, a third element is the extent to which participants need to ensure the usefulness and usability of the produced knowledge. Usefulness describes the potential value of to the user, without considering how easily picked-up and integrated into decision making (Lemos et al., 2012). Usability considers how easily can it be used to inform decision making (Clark et al., 2016) and needs to be credible (valid and reliable), salient (relevant), legitimate (respectful of the diverse values of its intended users) (Cash et al., 2003) and feasible (resources required are available) (Clark et al., 2016).

And finally, the third element, **problem-framing** looks into the sustainability challenge addressed. This can be studied by a team of interdisciplinary researchers, in collaboration with participants or by the participants themselves.

2. **Second dimension: synthesis (knowledge creation process)**

This dimension looks into the ***knowledge creation process*** that synthesises and/or integrates knowledge co-produced (Tengö et al. 2017). It covers the process design (format) and the activities (methods) (Lam et al. 2021). Some examples of activities are interdisciplinary workshops, interviews, surveys, data analysis and modelling (Lam et al. 2021).

3. **Third dimension: diffusion**

This dimension represents the transferable knowledge resulting from the process (Lang et al., 2012). ***Knowledge outputs and outcomes*** from knowledge co-production processes can be diverse (Schneider et a., 2019; Turnheim et al., 2015). Some examples are creating scientific knowledge as a product that is expected to shape policy or practice or through the development of knowledge dialogues, relations and ways of "doing" together. These can be tangible outputs and outcomes such as academic journal articles or policy reports for policy and practice or intangible, such as focusing on interactive dialogues and sharing practical experiences of involved actors (Christie et al., 2017; Charli-Joseph et al., 2018; Chatterton et al., 2018).

Potential usability of knowledge outputs looks into how the knowledge reaches the users and how it will be applied. Usability will be assessed based on who the intended users are, the knowledge type co-produced and whether it addresses the sustainability challenges from the user's standpoint (Barton et al., 2018). This can be achieved through the early involvement of users not only in the co-production of knowledge but also in the definition of the research aims (Marre and Billé, 2019), by the incorporation of insights from previous projects (Blackstock et al. 2007; Wall et al. 2017) and through the increase of trust over time by the researchers (Lemos et al., 2012). The usability of knowledge outputs can be improved through a participatory approach where the emphasis is placed on the process rather than the outcomes, thus enabling a much more effective approach to healing the soils by: Redistributing decision making power through the capacitation of citizens in evidence based decision making. Providing tools for citizens to participate and have their own independent voice (with more independence from certain market interests*). Enabling exponential reach to all interested parties to provide locally relevant knowledge in a timely manner and share it globally to inform better policy making - thus, speeding up the regeneration of the soil. Also fomenting the resilience of communities.

Chapter 4. Methodology

Research setting and design

The research is based on a case study approach which is suitable for research that seeks to explain a phenomenon "in-depth" and extensively (Yin, 2018, p. 33). The case study design I will apply is a multiple and embedded case study, see Figure 4.1 (Yin, 2018). By comparing multiple participatory soil health knowledge co-production processes, more clarity and understanding on their mechanisms and possible outcomes can be achieved. The research took place between March 2023 to June 2023.

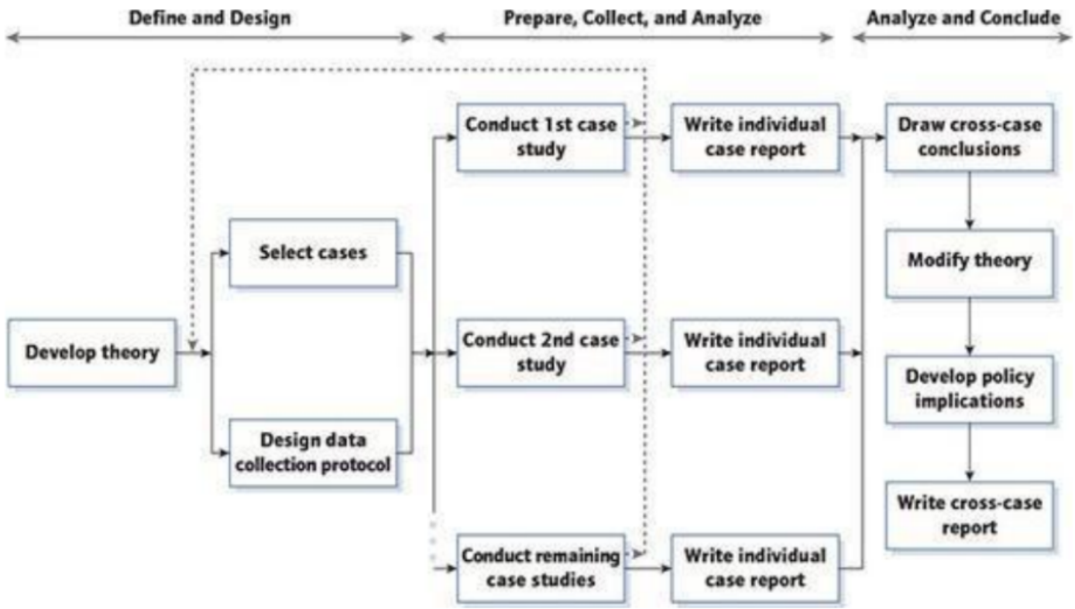


Figure 4.1. Multiple and embedded case study research design. Source: Yin, 2018.

Identification and selection of agroecological networks to be included in the study

I selected Rete Humus, Navdanya and EU soil living labs as case studies. This selection was based on the opportunity for interaction with the different actors, as well as the particular focus on soil health knowledge co-production in the agroecological context agroecological networks. I also included one knowledge co-production process, the EU soil living labs, which does not focus on agroecological networks in order to provide more insights to these processes.

The data collection method followed included semi-structured interviews, observations in the field when possible and desk research. The data analysis methods include qualitative methods in order to explore the soil health knowledge co-production processes. The analysis underwent an inductive approach by connecting the case and interview data to the analytical framework presented in Chapter 3. The reliability and validity of the data were taken into account throughout the whole research process. To address reliability, an interview guide was developed to gather information from diverse stakeholders based on the analytical framework. Furthermore, content validity was addressed through carefully designed interview protocols. This expert input ensured that the questions accurately captured the essential dimensions of soil health knowledge co-production. Construct validity was sought through triangulation, wherein multiple sources of data were used to corroborate findings. This involved interviews and field observations and academic publications.

Limitations

Some limitations of this research include time constraints to conduct more in depth research and participatory research, to include more interviewees representing more perspectives. It is important to take into account that these case studies do not aim to produce generalizable findings for broader contexts, but rather share insights into the different dynamics that are emerging.

Chapter 5. Results

This chapter presents the findings related to the diverse participatory approaches employed within soil health participatory approaches, in particular it looks into three case studies involving two agroecological networks, Rete Humus, in Italy and Navdanya, in India and one soil health network in development, the EU Soil Living Labs and Lighthouses. Through in-depth analysis of interviews, this chapter illuminates the various dimensions of the knowledge co-production process used to engage stakeholders in the co-production of soil health knowledge.

Case 1: Rete Humus

Table 5.1.1 Elements of the knowledge co-production process: Rete Humus.

RETE HUMUS - DIMENSIONS		
SETTINGS	SYNTHESIS	DIFFUSION
ELEMENTS OF THE KNOLWEDGE CO-PRODUCTION PROCESS		
• **Aims & Methodology:** Define and share good practices in agro-biological production and related product utilisation in the Unione Terre di Castelli, Italy. • **Contributing knowledge-holders and approach to participation:** trade associations, local economic operators, institutions, associations and schools as well as citizens, stakeholders in agriculture and biodiversity. • **Problem framing**: Modern large scale retail for agri-food production seeks to compete in the organic market and control international food production systems throguh iproprietary control of science and technology.	• **Knowledge creation process:** Participatory monitoring of biodiversity in organic farming and the territory. Bioblitzs. Citizen science.	• **Knowledge outputs and outcomes:** Rete Humus Guarantee for products. Opportunity for farmers to have a voice at the political levels. • **Usability of produced knowledge:** Citizens are better informed about products through the certificate and farmers can communicate better their efforts in soil regeneration and overall ecological practices.

Feedback mechanisms ensuring fit-for-purpose knowledge co-production

Rete Humus. (2023). Il Progetto. Retrieved from http://www.retehumus.it/il-progetto/

Note: own elaboration based on Rete Humus (2023).

Rete Humus is a social network for Italian bioagriculture located in the "Unione Terre di Castelli, Italy". The overall aim of the network is to define and share good practices in agro-biological production and related product utilisation based on principles and requirements of environmental and social responsibility, with the objective of fostering sustainability and solidarity among the different stakeholders (Rete Humus, 2023).

Aims and methodology.

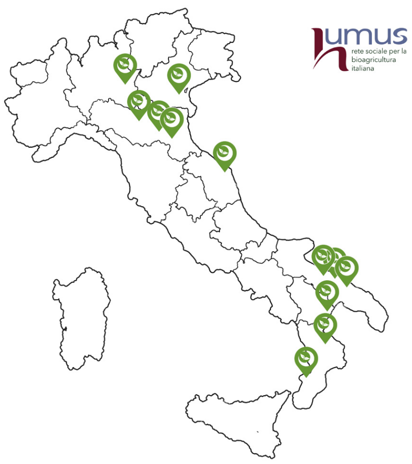
The project aims to define shared guidelines for a participatory biodiversity monitoring system. It is a research project shared with farmers to capture the soil characteristics alongside to social and cultural characteristics such as labour employed, training and professional development actions, strategies for labour inclusion of disadvantaged people, people with disabilities, marginalisation and immigrants or asylum seekers, activity in the territory and local community as well as their involvement in territorial short supply chains and local economy networks.

The methodology applied is "participatory monitoring" which gathers data at the farm level on the biodiversity of farms. The data gathered relates to the farm, its agricultural production, sustainable farming practices, apiculture, quality of the product, agrotourism and catering, the responsibility and justice and finally the "shovel test", which is based on the "Manual of auto evaluation of soil" available in Italian (Carbon on farm, 2018). This test is instructed to be carried out on a plot of the most important crop on the farm, in terms of spatial and economic size, which is representative of the soil and climatic conditions of the area. Where there are many farm variabilities within the farm, several tests and samplings can be carried out. This method of evaluating a soil sampling with a shovel is based on a visual assessment of soil quality based on the observation of a top soil sample removed with a shovel. The soil slice needs to be extracted intact and depending on the conditions, the sample should be 20-25 cm deep and 30-40 cm wide, as this depth is the most important zone for root development and plant growth, as well as the area with the greatest potential for negative effects on water infiltration, carbon losses on the soil etc (Carbon on farm, 2018, p. 3).

The basic idea is to use a method of self-evaluation of soil from the farmers who are working on the land. First, it is an easy and simple method, capable of giving indicators of daily activities. And second, aggregating the results, which are not always perfect. Thus, using the principles of citizen science, based on the number of observations, create statistical inferences (Rete Humus Coordinator, 2023).

Contributing knowledge-holders and approach to participation.

Figure 1.1.1 Rete Humus.



Note: Rete Humus, 2023.

Rete humus is a "social network" where a horizontal aggregation of economic organisations and civil society associations, which is also open to the individual expert contribution in order to give rise to new systems of participation of various protagonists in the affairs of organic farming and the rural territory. This the main knowledge contributors are farmers, trade associations, local economic operators, institutions, associations and schools, technicians as well as citizens (eg. bio blitz) and other stakeholders in agriculture and biodiversity.

The approach to participation has a networked approach, based on co-production principles in which various organisations operating in Italian organic agriculture come together to co-design shared guidelines for a participatory biodiversity monitoring system. The assessment of the environmental performance of the farm takes place through the detection of specific bio-indicators in the field and the determination of appropriate air, water and soil biodiversity indices, according to the principle "the more life there is in a territory, the less state the impact of human activities on it (Rete Humus, 2023)". On these bases, farmers, technicians and committed citizens can determine, also together with local institutions, a process of gradual and participatory improvement of the environmental performance of the agro-system, guaranteeing quality agricultural products and highly natural territories (Rete Humus, 2023)"

"*When conducting the tests, there are two or three people, a representative from Rete Humus, a technician who belongs to a second level organisation other than the farmer organisation (regional or locally based) and the farmer* (Rete Humus Coordinator, 2023)".

Problem framing.
The network participants "feel part of a generation that grew up and matured in the cultural impulse and ideal of an Italian organic agriculture (in the broader European context)" (Rete Humus, 2023). This movement gave way to productive, distributive and cultural-relational contexts and is becoming aware of a reality that is excessively governed by public policies and market interests, in which reference values are in danger of dispersing, values from which the results achieved so far derive (Rete Humus, 2023).

Rete Humus is part of an emerging sustainable and solidarity economy different from the dominant "mass consumption" economy (Rete Humus, 2023). The network emerged to think together about the future of organic farming in the country and agreed in the direction of strengthening the principles and constitutive values of Italian bioagriculture, then translating them into working methods and tools, shareable by the final recipients, the consumers (Rete Humus, 2023).

Even the adoption of voluntary standards and guidelines designed and developed in the countries of export of the products are not appropriate, because they do not adhere to the Italian reality and are not able to determine broad and widespread sharing in our society (Rete Humus, 2023).

There is an increasing trend in the growth of markets of organic and fair trade products globally, taking into account not only the intrinsic quality of the products, but also the environmental and social sustainability of companies and their products. There is an opportunity in the emerging new regulatory systems and instruments that favour small forms of agriculture. The risk concerns the sector being an object still of a bureaucratic and minimalist vision, more attentive to the formal aspects rather than the real content (environmental, social, health…), reducing the control of field activities to a residual practice (Rete Humus, 2023).

Knowledge creation process.

First, the manual to obtain the soil assessment characteristics was developed as part of the project LIFE CarbOnFarm in the context of the LIFE+ European funding program which was focused on safeguarding the environment and territory through the protection and safeguard of soil resources through the adoption of sustainable practices for the management of organic matter in agricultural soil. It was developed by a scientific working group and supported by five partners, representing the university of Naples Federico II, the University of Basilicata, the University of Turin, Regione Campania, Prima Luce - an agricultural organisation, CREA-OF - the Council for Research in Agriculture and Analysis of Agrarian Economy (Italian Agricultural Ministry) and the Agenzia Lucana for development and innovation in agriculture.

The knowledge creation process consisted of the organisation of participatory monitoring of biodiversity, farming and the territory through the application of *bio blitz*[6] and citizen science. First, there were around 15 pilot tests and the instrument was adapted. It has engaged up until now 110 cooperatives, peasants and enterprises in the soil test (Rete Humus Coordinator, 2023).

Knowledge outputs and outcomes.

According to Gliessman (2016)'s framework, Rete Humus is now reaching Level 4, as it is starting to connect citizens and local solidarity economies with their participatory soil monitoring.

Outputs: The evidence created through the questionnaire of what the farmers have observed in the soil, which an enable another outcome of having a base for an external to evaluate / obtain information (eg. consumer) (Rete Humus, 2023). Another knowledge output is the Hummus Guarantee for the products, which would uplift farmers from 3rd party guarantees that impose on farmers excessive bureaucratic burdens. The results of the farmer's self evaluation questionnaire on soil quality has not been yet published. Some preliminary observations show that the average carbon in the soil is larger than the Italian average and the biodiversity levels are significantly higher than the average (Rete Humus Coordinator, 2023).

Outcomes: This method also empowers the network to better understand the biological diversity status of agricultural areas, farms and territory as well as the impacts of human activities on the environment (Rete Humus, 2023). Out of this process, Rete Humus is developing its own demonstration farm for training and research, as well as demonstration.

[6] Periods of intense surveying for the recollection of biological data in a given area.

Furthermore, agronomic evidence is created, providing the possibility of developing an engagement process for improvement of the evidence and therefore enabling better planning of cultivation practices and their monitoring (Rete Humus Coordinator, 2023). This tool therefore can enable farmers, technicians and citizens to participate in the sustainable governance of the rural and agricultural territory (Rete Humus, 2023), creating an opportunity for farmers to have a voice at the political levels.

Usability of produced knowledge.

Citizens might be interested in environmental issues, good practices, and good and healthy products. They care about the food systems and also learn about the soil from a consumer perspective, as through this process, citizens can be better informed about products through the certificate of guarantee.

Farmers on the other hand, can communicate better their efforts in soil regeneration and overall ecological practices. Farmers are also usually quite proud of their results and may engage with the scientists in a discussion on what is happening on the soil which can go quite in-depth.

The process presents some weaknesses and threats in terms of the usability of knowledge produced. This method requires a strong participation of the Humus Network. There is a need for strong commitment, which is usually present on the second level (consumers, producers… organisations) but not always at the farmer's level. Furthermore, the producer - consumer relationship is aimed at being developed, but the participatory system is not yet ready experimented or operative (Rete Humus Coordinator, 2023).

On the other hand, there are several opportunities arising such as increasing the relationship with the "Rette de Economia Solidaria" (Rete Humus Coordinator, 2023), and the value added of a Certificate of Guarantee, in which farmers can showcase their work, which is not valued in the current system, as the organic certification does not value certain good agroecological practices yet. This research process can also become useful in the creation of trust relations among network members - "People are confident about what Humus is doing and Humus is confident that it can have a voice at the political level" (Rete Humus Coordinator, 2023). The network and research project is also useful for those who are looking for a political framework which supports their practice and commitment.

The strengths of the knowledge co-production process relate to the simplicity and ease of use of the tool and method, based on practicalities and learning by doing. Furthermore, the method is scientifically validated, and practical and provides immediate results which can be directly discussed with the farmers and/or participants. An open question emerged on what to prioritise, the practice and science or the organisation of the political voice for the agroecological movement (method vs political voice)? (Rete Humus Coordinator, 2023).

Feedback mechanisms ensuring fit-for-purpose knowledge co-production

Feedback is embedded throughout the whole process by means of the design of the process.

Case 2: Navdanya

Table 2.2.1. Elementos of the knowledge co-production process: Navdanya

NAVDANYA - DIMENSIONS		
SETTINGS	SYNTHESIS	DIFFUSION
ELEMENTS OF THE KNOLWEDGE CO-PRODUCTION PROCESS		
• **Aims & Methodology:** protection of Biological and Cultural diversity. Reclaiming the commons, Seeds sovereignty and Earth Democracy. • **Contributing knowledge-holders and approach to participation:** Farmers, Navdanya team. • **Problem framing**: Food is not a commodity produced with toxic and artificial chemicals pushing species to extinctions, driving climate change & spreading disease and pandemics. Food is life, health. Growing the food ecologically is care for the Earth and regeneration of soil, water and biodiversity.	• **Knowledge creation process:** Practical workshops and trainings on the regeneration of the soil with farmers in the context of their fields.	• **Knowledge outputs and outcomes:** Application and conservation of indigenous Knowledge on the reincorporation of organic matter (eg. vermicompost, liquid fertilizers, closing the nutrient cycles). • **Usability of produced knowledge:** Direct.
	Feedback mechanisms ensuring fit-for-purpose knowledge co-production	

Shiva, V., AGOSTINI, I., Bassey, N., Buiatti, M., Baranes, A., Brunori, G., ... & van der Ploeg, J. D. (2015). Terra Viva. Our Soil, Our Commons, Our Future. A new vision for Planetary Citizenship.

Aims and methodology.

The aim of the participatory approach to knowledge co-creation is the protection of Biological and Cultural diversity by reclaiming the Commons, Seed Sovereignty, Food Sovereignty and Earth Democracy (Navdanya, 2023).

The methodology applied in the knowledge co-production process involves the conservation and recuperation of indigenous practices of biodiversity farming centred in nature to recuperate "living seeds, living soil and living food". These practices in alignment with nature's cycles, can foster food security and soil security, in which there is diversity of seeds -adapted to the local climatic conditions- planted and minimal destruction of nature which creates more resilience in the food system. It is based on the understanding that all living has value within itself, thus a livelihood for all living species should be pursued (Thernsjö, 2018). Also, no artificial chemicals nor machines for ploughing are applied. Farmers are encouraged to use organic farming methods that regenerate the soil. In order to regenerate and maintain a living soil, some of the methods are to add green manure (Thernsjö, 2018), the use of vermicompost - compost in which you introduce organisms such as worms -, the development and use of organic fertilisers, liquid fertilisers coming from the animal manure, and closing the nutrient cycle by using the organic waste (manure, leaves…) that comes from framing activities to build their soil so that the habitat for organisms is favourable and plants can grow better (Navdanya Coordinator, 2023). Furthermore initiatives such as seed banks and microfinance groups also support the process.

Contributing knowledge-holders and approach to participation.

The contributing knowledge-holders are the farmers, the Navdanya team as well as Nature and the people who hold indigenous knowledge on farming. The approach to participation is led by the farmers themselves with the support of Navdanya. People who work with Navdanya teach other people about Navdanya and its work, as well as promoting Navdanya's aim. By empowering farmers to regenerate their soil, it becomes a participatory process in itself. Farmers can learn by applying these different techniques (Navdanya Coordinator, 2023).

Problem framing.

Navdanya puts the focus on the dominant industrial agriculture and food system which is based upon agricultural intensification and profit rather than the availability of food, its redistribution and the livelihood of farmers (Thernsjö, 2018). Furthermore, there is a deficient security net for small farmers when extreme weather events cause loss of yield and soil erosion (Thernsjö, 2018). Food is not a commodity produced with toxic and artificial chemicals pushing species to extinction, driving climate change and spreading disease and pandemics (Navdanya, 2023). Food is life, health. Growing the food ecologically is care for the Earth and regeneration of soil, water and biodiversity (Navdanya, 2023). Microbes such as fungi, bacteria, actinomycetes… and enzymes are organisms who process and fix nutrients in the soil, organic agriculture provides better environments for the organisms to thrive, in return, the health of the soil is better than under chemical farming (Rathore et al., 2018).

Knowledge creation process.

The knowledge creation process consists of practical workshops and training on the regeneration of the soil, together with knowledge on living seeds and living food, with the farmers in the contest of their fields. The training has been run over 25 years in 22 Indian states.

"We have developed a small proof type farm. The soil land we have here serves for doing soil testing, data analysis, microorganisms, soil temperature… Every year there is a new report. eg tests on earthworms casting. And there are a lot of experiments of mixed cropping of 3, 7, 12 crops… so that the farmers can get the best outcomes (Navdanya Coordinator, 2023)"

"In each region, there are local coordinators, who work directly with the farmers, who already tend to talk among themselves. The local coordinators work with different groups which are self-reliant. We support them to take the extractive economy out, in which every 4th person in the family has cancer, you rely on buying seeds and chemicals… and let the circular economy in, an economy in which they don't have to buy external inputs such as seeds, chemicals… and we help them with the rejuvenation of the soil (mixed cropping, compost…, permaculture, natural farming, organic farming, biodynamic farming… depends on the area of India - as it is a subcontinent and every area is very different) (Navdanya Coordinator, 2023)".

“Local coordinators provide reports and request the trainings they need and how often (eg. ecofeminism, soil, earth democracy…) and Navdanya has a few friends who provide the training according to what they need. If everyone needs training on a specific topic (eg. organic farming) we gather about 20 people from all across the country, covering the accomodation and travel cost. They train them with everything, starting with the seeds, how to breed them, treat them… also we let them take soil samples and look at them through the microscope and teach them what it looks like. It is very fascinating for them at the same time (Navdanya Coordinator, 2023)”.

“If there is a farmer who wants to change from chemical to organic. How much time does it take to regenerate the soil? What are the techniques to regenerate the soil? We have a few labs all across the country as we have friends who are testing the soil. But the participatory approach is not so much about technical assessment of the soil, there are many techniques. For example, you can see with your eyes. If you add some water to the soil and you make a ball, if you mould it and it keeps on getting long, you have too much clay. If it breaks down, you have too much sand. And if it is in between, then you have a good balance between both, which is needed. And also, if the topsoil has been washed away, how can we rejuvenate the topsoil? (Navdanya Coordinator, 2023)”

As a central part of the knowledge co-creation process are the seed banks. Navdanya has helped set up more than 150 seed banks in 20 out of 29 of India within thirty years and has trained and created awareness amongst 750,000 farmers (Navdanya, 2023). Through these banks, more than 4000 rice varieties and forgotten food crops such as millets, pseudo cereals and pulses have been collected, saved and conserved by Navdanya in the last 30 years (Navdanya, 2023). In the beginning a group of farmers is organised to collect, multiply and exchange traditional seeds and indigenous knowledge such as the know-how on cultivation, raising the seeds and organic pest management based on them, the members are responsible for the conservation of indigenous crop varieties becoming Seed Keepers (Navdanya, 2023). The farmer members collect available seeds in their village. Navdanya supports the task of obtaining seeds and managing the seed bank from farmers who cultivate them in the surrounding villages or existing seed banks from similar agro-climatic regions, and later on they run independently. In the community, farmers don’t have to buy the seeds. They just have to ask for them 6 months in advance. In the following harvest, the farmer has to return the same amount and add 25% more. These seeds are given to other farmers in the next season to multiply and increase the membership (Navdanya, 2023) Women farmers also try to change the whole community, enabling that everyone becomes organic and trains everyone in their towns. They get 5-6 years training to train other people in organic farming (Navdanya Coordinator, 2023).

“With regards to soil testing. We collect different soil samples, both from … we discuss with farmers the types of nutrients needed by the soil. How to improve nitrogen fixation without chemicals through green manuring, compost… (Navdanya Soil Scientist, 2023)”. In the laboratory, Navdanya measures the chemical and physical characteristics of the soil by using tools such as ph metre, rapid metres, measuring the NPK (nitrogen, phosphorus and potassium), soil's electrical conductivity, photo frame metre, colour metre, titration method for organic carbon… "The farmers don't know about the testing, but we speak the farmers' language. The farmers often know when the soil is alive or dead. It is alive if you can break the soil without any tools or by hand, it is quite soft. But you will need big machines if the soil is dead, it is compacted, like stone. Other indicators are the presence of earthworms and earthworm castings, pollinators around your crops (bees, butterflies…). Our farmers do organic farming, but not all of them know that the soil is living. The microscope allows them to see the bacteria, nematodes… the soil has life and learn the functions of bacteria that help decompose organic materials, absorb nutrients from the atmosphere, improve soil immunity, soil temperature… and that fungi can transport food for example. Scientific testing is still very important for the farmers, as they learn about the deficiency of specific nutrients on the soil. Scientists and experts discuss with farmers how to improve nitrogen in the soil through growing mixed cropping, as they absorb different nutrients, for example, potato fixes potassium (Navdanya Soil Scientist, 2023)".

Knowledge outputs and outcomes.

According to Gliessman (2016)'s framework, Navdanya has reached the highest level, number 5 which can be reflected on what they call Earth Democracy (Navdanya, 2023).

Outputs: Some knowledge outputs are the booklets developed in the workshops with the farmers which feed into Navdanya's publications that can be later used as manuals (Navdanya Coordinator, 2023). Navdanya goes village to village and collects success stories and shares them, and farmers often give some information about traditional seeds (Navdanya Soil Scientist, 2023).

Outcomes: Farmers already have an innate sense about the soil by looking at texture, the number of living organisms in the soil…. they might not necessarily require to use the soil lab as such. By using these methods of regeneration, the farmers themselves can already tell the differences between the chemically treated soil and the regenerative soil (Navdanya Coordinator, 2023).

Another outcome is the application and conservation of indigenous knowledge on the reincorporation of organic matter (eg. vermicompost, liquid fertilisers, closing the nutrient cycle). This knowledge comes from a traditional knowledge on how to work with the land, with the water… This is "farming with nature". This knowledge has been somewhat lost due to the green revolution and the industrialization of agriculture. An important part is to link them back to this knowledge and give them the tools to empower themselves. Because they know, but they are not able to implement it but they are stuck due to socio-economic reasons or because the system is such that they get stuck in the cycle of keeping using the chemicals. When they are given back the methods and empowered to use them, they can start to work on it (Navdanya Coordinator, 2023).

Usability of produced knowledge.
Navdanya's knowledge outputs and outcomes are an opportunity to eat healthy food, prevent illnesses, foster sovereignty of Seeds and independence from the use of chemicals, and farmers become self-reliant. Furthermore, farmers can feed the family first, then sell the crops. They can also become organic certified. The indigenous knowledge (from grandmothers, fathers…) is shared (Navdanya Coordinator, 2023).

Furthermore, "in India, most women are held back based on your gender. Through the knowledge co-production process, that kind of stereotype has been broken, women become self-reliant beyond the food they have, but also in making their own decisions. They start working with other women, creating a group, going out and sharing knowledge, pricing the goods… They become financially independent from their husbands and are able to support the family. Men often decide what to sell, how much to sell and for how much. In Rajasthan, women don't come out of their homes, after the training, they come out of their homes and most of them are elected as the local governing bodies eg. head of the village. We have given them strengths and tools on how to counteract that in a nonviolent way for the betterment of their future (Navdanya Coordinator, 2023)".

The strengths and usefulness of this process also translates into the creation of microfinance groups of about twenty women farmers each and the seed banks explained above. Farmers can add any amount in an account. There is a governing body elected every year by the twenty women with the roles of treasurer, a finance officer, president and vice president. When someone gets a loan, there is an interest that you pay. If someone would like to buy a cow they can ask for the money and then return it. The interest is 1% and it goes to the same account. This can be used for marriages as well. They don't have to depend on the husband to get their daughters married. Moreover, we have women who grow food. Around the world they work with "seeds of hope", for example, they were self-reliant and during the Covid-19 pandemic, they even supported the food supply of their communities.

On the other hand, some weaknesses had to do more with the start of the activities, "in the beginning you have a lot of pressure on women from the community or a male figure who doesn't allow them to get involved" but Navdanya works with women to create more opportunities. It is also harder identifying people, making sure we understand what they want, and making them understand what we want to help them with… (Navdanya Coordinator, 2023).

Navdanya's way of doing is that we don't force anything onto anyone. Navdanya is part of every big movement around the world. But Navdanya doesn't want to pressure anyone to change. We are only here to support.

Writing project proposals is not effective as they have mostly short term programs. In the end in these spaces you have to be fighting against the big corporations. The whole agriculture gets destroyed when you get involved. We had to come with something different. We study the circular economy in groups, for example, 30 farmers, 15 of them come to Dehradun, 13 ask questions, 5 think very much about it, 1 or 2 will apply what they have learnt. These 2 will make changes for the generations to come. This is a very slow process. With money you can create many things quickly and easily, but they collapse fast. If you write projects for funding, you are tied up, you destroy the relations of the people you are working with… because you ask for more things from them. Keeping it as free as possible, you get better results (Navdanya Coordinator, 2023). Navdanya works with small farmers in a long term process for the future and future generations, Navdanya promotes that if you have a little garden, you can grow your own food, so you are sustained (Navdanya Soil Scientist, 2023).

Some general threats are climate disaster such as extreme floods or droughts and the general threats that come from inorganic farming such as issues with the seeds, the land, illnesses, everyone selling the same thing and not getting the right prices. When practising organic farming, these threats are reduced significantly (Navdanya Coordinator, 2023). The blooming of many flowers usually happened at the end of February, beginning of March but due to climate change, it now happens at the beginning of January, this leads to crops being damaged due to the lack of rain and important wild flora and fauna which provide fodder, edible and medicinal plants is damaged as well (Navdanya Soil Scientist, 2023)..

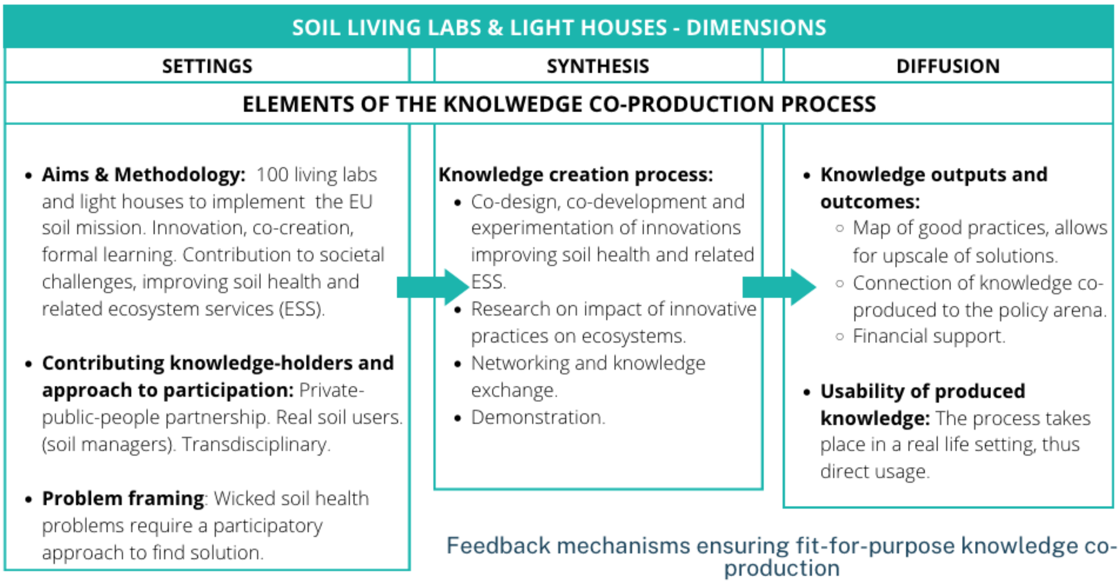
Some power dynamics affecting the usability of the knowledge produced are that men have more decision making power over the land and when working in groups, there is always someone who has more say on what is done with the collective funds (Navdanya Coordinators, 2023). In the area of soil health regeneration, farmers know about soil and farming, but the new generation don't know and are not interested in farming. Navdanya encourages children, youth and university students to go to their grandparents to collect traditional knowledge, such as how to maintain soil moisture? Mulching, transplanting more trees on the field border…, what were the traditional seeds and their technical know-how, what were the home remedies… This knowledge then is written in the community biodiversity register which contains a "Nature pharmacopia" for medicinal plants and "Nature harvest" for seeds and food plants (Navdanaya Soil Scientist, 2023).

Feedback mechanisms ensuring fit-for-purpose knowledge co-production

These are integrated in the process itself, as the farmers themselves are the ones driving the process based on their needs.

Case 3: Soil Living Labs and Lighthouses

Table 3.3.1. Elements of the knowledge co-production process: Soil Living Labs and Lighthouses



SOIL LIVING LABS & LIGHT HOUSES - DIMENSIONS		
SETTINGS	SYNTHESIS	DIFFUSION
ELEMENTS OF THE KNOLWEDGE CO-PRODUCTION PROCESS		
• **Aims & Methodology:** 100 living labs and light houses to implement the EU soil mission. Innovation, co-creation, formal learning. Contribution to societal challenges, improving soil health and related ecosystem services (ESS). • **Contributing knowledge-holders and approach to participation:** Private-public-people partnership. Real soil users. (soil managers). Transdisciplinary. • **Problem framing**: Wicked soil health problems require a participatory approach to find solution.	**Knowledge creation process:** • Co-design, co-development and experimentation of innovations improving soil health and related ESS. • Research on impact of innovative practices on ecosystems. • Networking and knowledge exchange. • Demonstration.	• **Knowledge outputs and outcomes:** ◦ Map of good practices, allows for upscale of solutions. ◦ Connection of knowledge co-produced to the policy arena. ◦ Financial support. • **Usability of produced knowledge:** The process takes place in a real life setting, thus direct usage.
	Feedback mechanisms ensuring fit-for-purpose knowledge co-production	

Couture, Isabelle, & Grbović, Vladislava. (2023, June 22). Living Lab Essentials & How to set up a Living Lab. Zenodo. https://doi.org/10.5281/zenodo.8073797

The European Commission (EU) has established as one of its five missions "Soil Health and Food" in its "Soil Deal for Europe" as part of the new Horizon Europe Framework Program of Research and Innovation for the period 2021 to 2027. This mission links to the SDGs, the European Green Deal and the EU Soil Strategy (EC, 2021). The Horizon Europe Mission, "A soil deal for Europe" defines Soil health as "*the continued capacity of soils to support ecosystem services, in line with the Sustainable Development Goals and the Green Deal*" (Veerman et al., 2020).

Figure 2.2. European Commission's timeline: Proposal for a Soil Monitoring Law.

Note: European Commission (2023)

As shown in Figure 2.2, on the 5th of July, the EC presented the first proposal to regulate the monitoring of protected soils by providing a "harmonised definition" and a monitoring framework for soil using EU data. This proposal does not contain binding protection measures mentioned in the strategy from 2021, and the European Court of Auditors labelled EU efforts for sustainable soil management "*unambitious standards and limited targeting"* (ECA, 2023).

The European Commission (EC) has presented the Mission concept that requires joint learning between farmers, scientists and citizens. It is a way to directly create concrete solutions to some of our biggest societal challenges, being the restoration of soil health, one of them (European Commission, 2021). For the soil mission, "living labs" are proposed that should evolve into "lighthouses" when environmental thresholds for each of at least six land-related ecosystem services are met. This presents "wicked" problems that can be "tamed" by measuring indicators for ecosystem services that are associated with the land-related SDGs in a given living lab (Bouma, 2022).

Thresholds with a character that is occasionally regional are needed to separate the "good" from the "not yet good enough". Contributions by the soil to ecosystem services can be expressed by assessing soil health. By introducing the mission concept, the policy arena challenges the research community to rise to the occasion by developing effective interaction models with farmers and citizens that can be the foundation for innovative and effective environmental rules and regulations (Bouma, 2022).

The mission's goal, A Soil Deal for Europe is to implement 100 living labs and lighthouses to lead the transition to healthy soils by 2030 which is part of the EU's ambition to reach 100% of healthy soils[7] by 2050 (European Commission, 2021). This goal is accompanied by eight specific objectives and their target baselines and soil health indicators which can be found in Table 3.3.2., including the reduction of land degradation due to desertification, conserving and increasing soil organic carbon stocks, stopping the increase of soil sealing and the increase of reuse of urban soils, the reduction of soil pollution and restoration enhancement, the prevention of erosion, the improvement of soil structure, the reduction of EU's global footprint on soils and the increase of soil literacy in society across Member States.

[7] Soil health is defined in the Implementation Plan as "the continued capacity of soils to support ecosystem services (EC, 2021) whereas ecosystem services are "understood as the services provided and the benefits people derive from these services, both at the ecosystem and at the landscape scale, including public goods related to the wider ecosystem functioning and society well-being" (Haines-Young and Potschin 2018; MA 2005).

Table 3.3.2. The mission's specific objectives, targets and proposed soil health indicators

Mission Goal: 100 living labs and lighthouses to lead the transition towards healthy soils by 2030			
Objectives	Mission targets in line with EU and global commitments	Baseline (see 8.A)	Soil health indicators
1.Reduce land degradation relating to desertification	T 1.1: Halt desertification to help achieve land degradation neutrality and start restoration -- In line with SDG 15.3	25% of land in Southern, Central and Eastern Europe at risk of desertification.	All eight soil health indicators
2.Conserve and increase soil organic carbon stocks	T 2.1: Current carbon concentration losses on cultivated land (0.5% per year) are reversed to an increase by 0.1-0.4% per year T 2.2: the area of peatlands and wetlands losing carbon is reduced and the natural sink is significantly increased to help meet GHG reduction targets by 2030 and the Climate law goal by 2050. -- In line with the Fit for 55 Climate Energy Package (Climate Law, revised LULUCF regulation) and the Paris Agreement 4 per mille initiative.	Area of land with low and declining carbon stocks = 23%. Area of degraded peatland = 4.8%	Soil organic carbon stock Vegetation cover
3.No net soil sealing and increase the reuse of urban soils	T 3.1: increase urban recycling of land beyond 13% and switch from 2.4% to no net soil sealing as a contribution towards meeting the target of no net land take by 2050. -- In line with Roadmap to a resource efficient Europe, and Biodiversity Strategy including upcoming nature restoration targets	Area of land affected by soil sealing = about <1% of EU, but can be as high as 2.4%, Current rate of recycling of urban land for development: 13%	Soil structure (incl. soil bulk density, absence of soil sealing, erosion and water infiltration) Vegetation cover
4.Reduce soil pollution and enhance restoration	T 4.1: reduce the overall use and risk of chemical pesticides by 50% and the use of more hazardous pesticides by 50% T 4.2 reducing fertilizer use by at least 20% T 4.3: reduce nutrient losses by at least 50% T 4.4: 25% of land under organic farming T 4.5: Reduce microplastics released to soils to meet 30% target of zero pollution action plan T.4.6 Halt and reduce secondary Salinization All to be achieved by 2030 to contribute to meeting the target by 2050 that soil pollution is reduced to levels no longer considered harmful to health and natural ecosystems. -- In line with the Biodiversity strategy, the Farm to Fork Strategy and the Zero Pollution Action plan.	27% - 31% of land with excess nutrient pollution Soil contamination: 2.5% (non-agricultural), 21% (conventional arable), ca. 40-80% of land from atmospheric deposition depending on the pollutant. Farmland under organic agriculture: 8.5% (2019)	Presence of soil pollutants, excess nutrients and salts

5.Prevent erosion	T 5.1: reduce the area of land currently affected by unsustainable erosion from 25% to sustainable levels --- In line with the Roadmap to a resource efficient Europe	Area of land with unsustainable soil water erosion is 25%, with 70% of this being agricultural land.	Soil structure, absence of soil sealing, erosion and water infiltration Vegetation cover Landscape heterogeneity Forest cover
6.Improve soil structure to enhance habitat quality for soil biota and crops	T 6.1: Reduce compaction of soils to go significantly below current levels of 23% - 33% --- As for forest soils: in line with the new EU Forest Strategy	Area of land with critical levels of soil compaction = 23-33%, 7% of which is outside agricultural area.	Soil structure, absence of soil sealing, erosion and water infiltration. Vegetation cover Landscape heterogeneity
7.Reduce the EU global footprint on soils	T 7.1: Establish the EU's global soil footprint in line with international standards T 7.2: The impact of EU's food, timber and biomass imports on land degradation elsewhere is significantly reduced without creating trade-offs --- In line with the Zero Pollution Action Plan	Baseline to be created by mission activities	Food, feed and fibre imports leading to land degradation and deforestation
8.Increase soil literacy in society across Member States	T. 8.1: awareness of the societal role and value of soil is increased amongst EU citizens, including in key stakeholder groups, and policy makers T. 8.2: soil health is firmly embedded in schools and educational curricula, to enable citizens' behavioural change towards the adoption of sustainable practices both individually and collectively. T 8.3: citizen involvement in soil and land-related issues is improved at all levels T 8.4: practitioners and stakeholders have access to appropriate information and training to improve skills and to support the adoption of sustainable land management practices.		All eight indicators (on a long term)

Note: European Commission, 2021, pp.17-18.

Up until now there have been funding calls for soil living labs for carbon farming specifically and a general call for SLLs. The European Agroecology Living Lab and Research Infrastructure Network (ALL-Ready) is in its preparation phase for the agroecological partnership starting in 2024 as part of the Horizon Europe 2020 (ALL-READY, 2023).

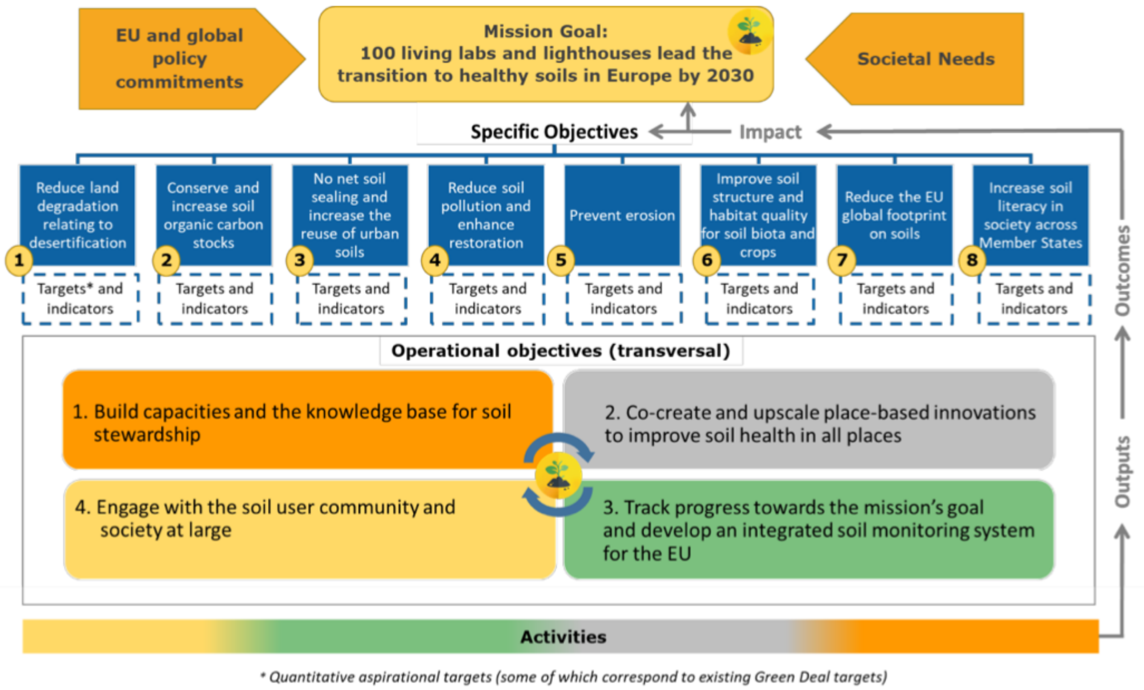
There are ten main projects in the area of soil, which are preparing the ground for the implementation of the Soil Mission. These are the HuMUS project (CORDIS, 2023) aiming to engage municipalities and regions through the creation of spaces for dialogue on soil health, including marginalised and vulnerable parts of society. Nati00ns is the help desk that supports funding applications for the Soil Mission (Nati00ns, 2023). SOLO aims to co-create and identify knowledge gaps, BENCHMARKS and AI4SoilHeath will validate and further develop indicators to measure, monitor and assess soil health and functions using integrated frameworks and Artificial Intelligence (REA, 2023). SOIL O-LIVE will explore the connections between soil health and nutritional and safe food whereas INBESTSOIL will test the incorporation of an economic valuation system of ecosystem services based on five business models. NOVASOIL will focus on studying four business models allowing the creation of new incentives from healthy soils and SOILVALUES will explore financial mechanisms such as equity investment or compensation for risk or cost reduction, as well as hybrid incentive schemes and develop at least six business models to help land manages to make decisions (REA, 2023). NBSoil will support the next generation of soil advisors through a learning program on a holistic approach to soil health through nature-based solutions (REA, 2023). Finally PREPSOIL has been preparing the ground for the Mission, healthy soils and building capacities for engagement, outreach and knowledge (REA, 2023).

A good example of a Living Lab is ÖMKi, an on-farm research network which carries innovative experiments on Hungarian organic farms, established in 2012 it is based on the active participation of farmers researching topics such as inter-row cover crop seed tests, cereal varieties tests and remote sensing (ÖMKi, 2023).

Aims and methodology.

The aims focus on innovating, co-creating and achieving formal learning, contributing to societal challenges, and improving soil health and related ecosystem services as well as the mission objectives (EC, 2021, p. 31).

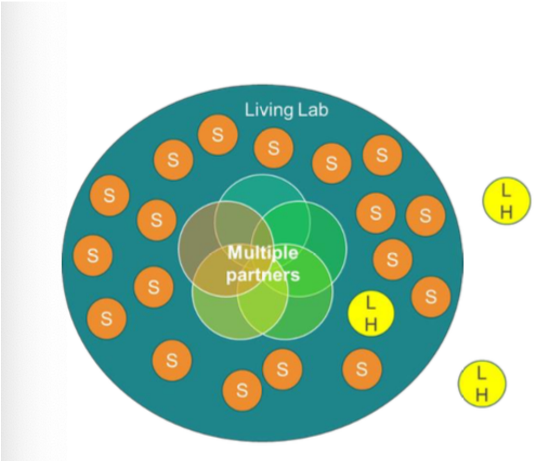
Figure 3.3.1. Schematic view of the mission's intervention logic.



Note: European Commission, 2021, p.18.

The second transversal operational objective relates to the Living Labs (LLs) and Lighthouses (LHs), see Figure 3.3.2, which are a methodology aimed at "accelerating the creation and uptake of solutions to meet the specific objectives across frames, forest, landscapes and urban settings in a diversity of geographical and socio-economic context" (EC, 2021, p. 18). Soil Health Living Labs are defined as *"user-centred, place-based, and transdisciplinary research and innovation ecosystems, which involve land managers, scientists, and other relevant partners in systemic research and codesign, testing, monitoring and evaluation of solutions, in real-life settings, to improve their effectiveness for soil health and accelerate adoption. These Living Labs are collaborations between multiple partners that operate at regional or sub-regional level and coordinate experiments on several sites within a regional or sub-regional area (or working landscapes)* (EC, 2021, p.28)". *"Lighthouses" are defined as "places for demonstration of solutions, training and communication that are exemplary in their performance in terms of soil health improvement". They are local sites (one farm, one forest exploitation, one industrial site, one urban city green area, etc.) that can be included in a living lab area or be situated outside a living lab area* (EC, 2021, p.28).

Figure 3.3.2. Visualisation of scales and activities of living labs and lighthouses



	Scale	Activities	Performance in soil health improvement
Living lab	Regional/sub-regional landscape	Coordinate experimentations & partners	In progress at landscape scale
Living lab experimentation site	Local (one farm/forest, one urban site, etc.)	Co-create knowledge and innovations	In progress on the site
Lighthouse	Local (one farm/forest, one urban site.)	Experiment and/or demonstrate	Demonstrated high performance

Note: European Commission, 2021, p.29.

The three main activities are first, to carry out engagement sessions with Member States and regions to build capacities for living labs and lighthouses. Second, to create an EU support structure for the network of soil health living labs and lighthouses and third, to create transnational clusters of living labs.

Contributing knowledge-holders and approach to participation.

These are public-private-people partnerships, real users such as soil managers connected with broad array of stakeholders and decision makers and the wider public, policy arena, EIP and relevant networks (McPhee et al., 2021), that is what is often called the quintuple helix representing academia, industry, government, civil society and the natural environment (Carayannis et al., 2012).

The approach to participation is based on a multidisciplinarity, transdisciplinarity and multi-scale approach to methods, and dimensions (economic, technical and social) (EC, 2021). If the LLs are well implemented that leads to true engagement, which is supported by legal collaboration frameworks which are financially and politically supported such as it is the case for energy communities in specific territories (ENOLL Rural Living Lab, 2023).

Problem framing.
60-70% of European soils are degraded, to achieve 100% healthy soils by 2050, 100 LLs & LHs should be co-created.

Knowledge creation process.
It is based on the co-design, co-development and experimentation of innovations improving soil health and related Ecosystem Services (ESS) as well as the development of research on impact of innovative practices on ecosystems, the establishment of networking and knowledge exchange and through demonstration of best practices (LHs).

Currently, the soil needs are being carried out in 21 European regions representing a variety of soil needs based on the land use types, agricultural, urban/industrial, forestry/nature and mixed land use. These were selected based on the unsustainable land uses (Prepsoil, 2023). PREPSOIL is the continuation of the Soil Mission Support project, which developed a systems framework for the collection of knowledge needs on soil health at the European level (Löbmann et al., 2022). Figures 3.3.3 and 3.3.4 provide the systemc relationships between soil challenges related to soil and land as well as the systemic relationship between knowledge types (Löbmann et al., 2022).

Knowledge outputs and outcomes.
According to Gliessman (2016)'s framework, the SLLs and LHs' level in the agroecological transition will depend on the living lab itself. The interviews reveal that no particular Soil LL focused on soils specifically. However, there are agroecological LLs which

Outputs: "100 LLs created in at least 100 regions, each LL being composed of 10-20 individual experimental sites and at least one lighthouse, covering all land-use types, such as farms, urban and industrial soil delivering knowledge on socio-economic, cultural and behavioural drivers of the adoption of innovations or beneficial practices, test and validate land or soil management practices with significant soil health improvement and uptake potential, practise proof monitoring technologies and indicators and creating demonstration activities and events on lighthouse and other experimental sites in rural and urban areas as well as providing input research and innovation needs form practitioners and citizens (EC, 2021)".

"One European soil health living lab and lighthouse network providing methodological support on the creation of LLs, an interactive map showcasing the network, knowledge exchange activities on mission objectives and training and dissemination material to spur uptake and scale-up of beneficial practices by land managers in and beyond the living lab arenas (EC, 2021, p.33)”.

Outcomes: “Improved awareness by land managers of soil health challenges (objectives 1-6) and uptake of innovative solutions in living lab areas and beyond; Measurable improvement of soil health, at least in the living lab areas, as manifested by criteria developed under the soil health monitoring programme for mission objectives 1-6; Increased social capital (norms, networks, relations between actors) in regions where living labs have been developed, triggering further positive long-term developments in soil health and ecosystem services related domains; Improved citizen awareness in the regions where living labs have been developed (outcome achieved in cooperation with activities under operational objective 4) (EC, 2021, p.33)”.

Usability of produced knowledge.
The knowledge co-production process takes place in a concrete place and real-life context and is supported by a scientific setup for ecosystem assessment. This approach ensures that the data required to feed the policy process as well as the EU Soil Observatory is available, while balancing and responding to the needs of specific SLLs.

On the side of strengths, the methodology is robust if well applied (ENOLL Rural Living Lab, 2023). In terms of weaknesses, the SLLs & LHs will feed data into the EU Soil Observatory. These are relatively new initiatives as compared to other EU missions, soil is a new field. The first project funded on soil is the European Joint Programme Soil which only started in 2020 (ENOLL Project Manager, 2023). Hence, the quality and quantity of soil knowledge is not of enough quality and soil data is not harmonised despite initiatives for open linked data (ENOLL Rural Living Lab, 2023). This is due to the significant disparity between cartographic systems among member states and the complexity of soils (ENOLL Rural Living Lab, 2023). The LLs require sustainability in time, that is, that it continues beyond the financing of the project. This is quite rare at the national and regional levels, however, the local levels often continue with or without the project as they have communities linked to the territory to back them up. It is important not to keep reinventing the wheel and start using the solutions, but there is a cultural barrier. LLs have the potential to support better decision making, by catalysing collective learning and collective decision making for optimal decisions.

Several opportunities for the SLLs have to do with the need for participatory approaches to sustainability challenges such as what is happening in the Mar Menor due to the intensive agriculture nearby, in Spain. The excessive use of fertilisers has had an impact in the Mar Menor in which the sea water is undergoing eutrophisation, thus killing the marine ecosystems (ENOLL Rural Living Lab, 2023).

The SLLs & LHs should aim at having some convergence and interoperability, also with other policy tools and initiatives such as the Common Agricultural Policy (CAP), which is for instance, already requiring the monitoring of the land and the follow up of fertilisation schemes (ENOLL Rural Living Lab, 2023).

For the knowledge to be usable, it is essential to have the proportional representation and representativity of stakeholders to the part of the society it aims to engage in co-production efforts (ENOLL Rural Living Lab, 2023). That means that each of the stakeholders needs to be present and use the LL together. For example, including grandparents or farmers who can also later on pass the knowledge to their own social networks (ENOLL Rural Living Lab, 2023).

Furthermore, data is the gold of the future, however many farmers have to trust when approached by these types of projects. When establishing partnerships farmers need to be engaged from the onset, also in the definition of project objectives and their time and knowledge needs to be recognised, respected and valued through economic compensation of their time, provision of free services for example (ENOLL Rural Living Lab, 2023).

Some potential threats for the LLs are: It is also really important to still adapt to the cultural heritage of food and agriculture in Latin América and many mediterranean countries. It is important to look into the cultural cases of the country to see how collective decision making took place and still takes place in settings like neighbourhood communities, community networks… and if these structures still exist, they should be reinforced through active participation. With the use of ICT participation of the community in decision making even if it is not all the time in the territory is possible (ENOLL Rural Living Lab, 2023).

The local community must also know about the SLLs (ENOLL Rural Living Lab, 2023). Farmers have a lot of knowledge on traditional solutions that have been used throughout history, but this is being lost due to the generational change.

With the Common Agricultural Policy, farmers need to make a follow up of the fertilisation of the land. Copernicus is a European Agency that monitors the Earth and environment through a constellation of satellites making daily observations and making use of a global network of land, air and marine-based sensors. This allows us to make inferences through artificial intelligence on the state of the plants, water and soil components, the calculation of carbon balances, nitrogen balance and many others which allows making decisions. There is also a significant risk to deepen the digital divide that already exists (ENOLL Rural Living Lab, 2023).

Feedback mechanisms ensuring fit-for-purpose knowledge co-production

While these mechanisms are not always used, they can take the form of feedback workshops and validation sessions or questionnaires (ENOLL Rural Living Lab, 2023).

Conclusion

This chapter unveils the multifaceted elements that guide the co-production of soil health knowledge within different soil-related networks. The knowledge co-production process differs significantly between the two agroecological networks and the non-agroecological network. Soil health knowledge co-production processes are still emerging but the preliminary insights reveal the importance of communities as actors with agency in the transition of a food system that is more socially just and ecological. As the exploration continues, the subsequent chapter engages in a discussion of the research findings, offering insights into the implications and interconnectedness of these elements.

Chapter 6. Cross-Case Analysis and Discussion

The findings of this thesis shed light on the significance of participatory approaches in co-producing soil health knowledge. Through the case studies, it became evident that the integration of indigenous wisdom, community engagement, and scientific insights can lead to a holistic understanding of soil health. The findings underscored the potential of soil living labs in bridging the gap between traditional ecological knowledge and contemporary soil science.

Answering the first research question: What participatory approaches exist to soil health knowledge co-production in agroecological networks? The results from the in depth analysis of soil health knowledge co-production in Rete Humus, Navdanya and the Soil LL and Lighthouses reveal the diversity of participatory approaches that exist ranging from participatory biodiversity monitoring, agroecological trainings on reincorporating organic matter into the soil, recovery safeguard and application of indigenous and ancestral knowledge, seed banks, soil living labs and lighthouses and many more.

The second question asks what are the elements (settings, synthesis and diffusion) of the soil health knowledge co-production processes within these agroecological networks? In summary, the question reveals the myriad of agroecological constellations and soil health participatory tools available, and provide a fertile ground to reflect on the factors and processes that make co-production useful. It also allows us to better understand the practical challenges and opportunities to deepen the co-production of knowledge in general and in the context of soil health. The underlying motivations and modes of engagement. Which problems are being addressed, how and to what effect? And how can we improve the knowledge co-production process?

A summary of the main elements can be found below through a cross-case comparison of the results. It is important to acknowledge the difference of contexts and scales, the cross-case comparison is done with the purpose of gaining deeper understanding on different features and characteristics of each of the case studies.

Fist dimension: settings

Research aims and methodologies

The aims were rather aligned between the agroecological networks, focusing on achieving different levels of farmer's emancipation. For Rete Humus, from bureaucratic hurdles of Certificates of Guarantee of origin and defining good practices in the bio-organic agricultural production of the network and for Navdanya holistically emancipate from an extractivist economy to a circular one based on food, seeds and Earth Democracy. On the other hand, the SLLs and LHs left room for the definition of the main aims, given that at the moment it is a transnational soil network in development.

The methodologies across cases were also quite different, from participatory monitoring of biodiversity and socio-cultural practices in Rete Humus to the ecofeminist agroecological trainings, seed banks and microfinance groups of Navdanya to SLLs and Lighthouses with examples of participatory research.

Contributing knowledge-holders and approach to participation

The three case studies engaged a broad range of societal stakeholders, for Rete Humus, predominantly farmers, researchers and other civil society organisations, with the initiation of involving citizens and in Rete Humus. We can observe a knowledge co-production process which is mostly led by researchers, with high levels of engagement from civil society organisations and to a lesser extent farmers. In Navdanya we observe a farmer-to-farmer type of dynamic with the support of the Navdanya team. The process is clearly driven by farmers themselves, who self organise and empower themselves through the network. Significantly different approach can be found in the SLLs and LHs for instance are the ones who more strongly involve governmental institutions, as the are part of a European Commission-led mission, it is also reflected in the balanced approach between researchers, government, academia, businesses, civil society and the natural environment. While still advocating for high participation on the ground, the desire to provide feedback to policy is a unique feature among these three cases.

Problem framing

Rete Humus and Navdanya had a clear focus on reframing the problem and solutions placing the current industrial agriculture food system as the driving force behind soil health loss. On the other hand the Soil Living Labs and Lighthouses focus on framing to find solutions to soil health degradation.

Second dimension: synthesis

With regards to the knowledge creation process, the synthesis of knowledge takes place through a questionnaire for Rete Humus, with the involvement of a representative of Rete Humus, a farmer and sometimes a civil society representative. For Navdanya the knowledge synthesis takes place during workshops and interactions with farmers, community elders and the community at large. Finally, for the SLLs and LHs, the synthesis depends on each case. For a good practice LL involved in organic agriculture it happened through the test of different types of crops and crop mixtures as well as through the engagement in monitoring for this research.

Third dimension: diffusion

Knowledge outputs and outcomes

The knowledge outputs and outcomes are very diverse. For Rete Humus, one of the most relevant outputs is the certificate of origin and the activation of the network in knowledge co-production and sharing. For Navdanya one of the most significant outcomes is the emancipation of farmers from extractivist economies, but also the emancipation of women, which in the Indian context is quite a challenge. Some other outputs are the agroecology manuals co-created with the farmers in their training and exchanges of good practices. In the

SLL & LHs, the outputs and outcomes differ from case to case, for the LL applying organic agriculture some knowledge outputs have to do with the better understanding of which seeds do better where and how they should be combined.

Potential usability of knowledge outputs

The usability of knowledge outputs depends on the end user and its application. To date, some knowledge outputs are still in development, such as the Certificate of Origin for Rete Humus. The participatory monitoring system creates a questionnaire which can be useful to citizens interested in these topics and joining a consumption group, and it can also be useful for farmers to better understand their soil, learn about new practices and share their results with the local social and solidarity networks. Navdanya's knowledge outputs allow communities to eat healthy food, prevent illnesses, achieve food and seeds sovereignty and may provide some financial independence for women while preserving indigenous wisdom. Navdanya' case study reveals how scientific knowledge on soil health can be of use to farmers to learn more about the nutrition needs of their soil, However recognizing how knowledgeable farmers already are on their soil, and also realising that even without the scientific tools, farmers can know about the health of the soil. This is also corroborated by the type of methods relying on visual assessment of soil deployed by Rete Humus. Looking into the texture of the soil, it's macro organisms (eg. worms) can already give a lot of information about the health of the soil. And then what becomes relevant is to introduce practices that are regenerative for the soil, such as the introduction of organic matter via composting, green manuring, vermicompost, intermixing crops to fixate different nutrients to the soil, and many other techniques. For the SLLs & LHs, the usability depends on the different cases, using the example of the organic LL the knowledge can create more ecological resilience in the farms, local ecology and their communities.

Feedback mechanisms ensuring fit-for-purpose knowledge co-production

The feedback mechanisms are important as part of a comprehensive process which is able to redirect itself.

Improvements to the soil health knowledge co-production process

The case studies also reveal multiple possible improvements for the process. One of the main challenges that could be taken into account is the potential loss of the knowledge outputs if they are not valued enough due to the generational change. Furthermore, knowledge outputs and outcomes are shaped by the types of engagement needs and capacities of researchers and participants and should therefore be designed accordingly. Placing local communities at the heart of the process can support its longevity in the long term, beyond the current short-term project lifecycle. The representative inclusion of all relevant stakeholders during the knowledge creation processes enables more impact and usability of knowledge outputs.

Limitations

Some limitations of the present study include the potential bias introduced by the researcher's interpretation and the contextual specificity of the cases, the missing perspectives due to a short period of research. And constraints linked to the availability of resources, time limitations, and lack of opportunities to implement an action research approach. Further research should be conducted from first hand experience of farmers. These limitations require engagement in reflection, inquiry and documentation of co-production processes to foster more collaborative and equitable knowledge development.

Implications

The research offers several noteworthy implications. *Knowledge co-creation is particularly suitable for the science, practice, and movement of agroecology, given the importance of participatory and farmer-centred processes and outcomes (Utter et al., 2021).* Firstly, the adaptability of knowledge co-production strategies based on local context was highlighted. The case studies demonstrated that tailoring participatory methods to the specific needs and preferences of each network enhances engagement and the relevance of knowledge outputs.

Secondly, enabling an agroecological transition can improve the health of the soil by introducing more ecological practices in agriculture on the one hand, but also going beyond the farm. As the Navdanya case shows, the emancipation from an extractive economy towards a circular one trickles other effects allowing for the emancipation of the women farmers themselves. While multiple agroecologies exists, the underlying principles significantly differ on the extent to which they challenge and seek to transform power structures, fight for land and the defence of the territory, depatriarchalizing and decolonizing (Giraldo and Rosset, 2023).

Thirdly, the importance of ancestral, indigenous and traditional knowledge that is localised is enormous, especially in the context of soil regeneration giving its complexity and diversity. The case studies show that the loss of this type of knowledge could be irreversible, and that strategies to conserve it are needed. Aiming to increase the autonomy of agroecology also translates into more self-governance by communities, and therefore more democratic decision-making.

Fourthly, knowledge co-production on soil within agroecological networks also supports engagement with the community in local markets and social and solidarity economies. Furthermore, these types of processes have the potential to activate and strengthen collective problem solving, values sources of wealth that cannot be monetized. Enable the dialogue of different types of knowledge in a rather horizontal and peer-to-peer approach and foster worldviews there are more in equilibrium with nature, allowing for the development of connection to the land and the people.

In conclusion, this research demonstrates that inspiring and useful insights can be drawn from Rete Humus, Navdanya and the SLLs, but particular transformative outcomes and knowledge outputs are characteristic of the agroecological networks. The networks co-produce soil health knowledge and use it to transform the food systems in a way that it also impacts the way we relate to one another and perhaps even the way we see the world. The findings call for the prioritisation of protecting, respecting and recuperating different types of knowledge.

By placing local communities at the heart of soil health knowledge, co-production practices can be improved, contributing to the regeneration of soil health, the protection of biodiversity, ecosystems and societal health, for the current generations and those yet to come.

Chapter 7. Conclusions

Life on Earth depends on a living soil. If we are to regenerate our soil and bring it back to life, we will certainly require participatory tools like the ones explored in these thesis. This thesis has examined the processes of soil health knowledge co-production within agroecological and soil networks. In particular, I have analysed three case studies, Rete Humus, Navanya and the Soil Living Labs and Lighthouses revealing their approaches to participation in the context of soil regeneration and the different elements that conform them. This final chapter summarises the primary findings and underlines the distinct contribution that agroecology can bring to soil health knowledge co-production processes to support the transformation of our food systems towards more just, healthy and sustainable ones. The findings derived from this research call for further investigating soil health knowledge co-production in agroecological networks spanning different geographical regions and case studies.

The first research question asked "What participatory approaches exist to soil health knowledge co-production in agroecological networks?" in view to explore where they take place, their characteristics, the conditions for their emergence and the challenges that arise within them (Utter et al., 2021). The results of the three case studies reveal the diversity of participatory approaches to soil-health knowledge co-production encompassing participatory soil biodiversity monitoring, agroecological training on soil regenerative practices such as reincorporating organic matter into the soil, the recovery, safeguard and application of indigenous and ancestral knowledge, seed banks, soil living labs and lighthouses among others. These approaches showcase the significant diversity of methods, each carefully tailored to distinct contexts and objectives of their respective networks.

The second question asked about the elements (settings, synthesis and diffusion) of the soil health knowledge co-production processes within these agroecological networks? The aim was to go deeper into the understanding of the elements in soil health knowledge co-production processes with a view to observe which level of food system transformation is activated by the process. The case studies reveal that participatory soil health knowledge co-production in agroecological networks is a methodology with significant transformative potential which can activate emancipatory social processes and catalyse the agroecological transition at its highest levels (4 and 5) (Gliessman, 2016). The agroecological transition would be then linked to the implementation of regenerative soil practices.

The case studies have also revealed practical challenges. Transforming food systems is not a minor endeavour and requires a long term vision which often links to the construction of food sovereignty in the territory (Martínez-Torres and Rosset, 2017), this means that the processes work better with active local communities, so that they can sustain the projects into the future. Another challenge has to do with the need of creating inclusive and representative spaces for collaboration, where the relevant stakeholders are represented in numbers similar to proportion of the population they represent (ENOLL Rural LL, 2023). Addressing this challenge can support the management of emergent power dynamics. Furthermore, there is an urgent need to going beyond what Sousa Santos, (2009) denominates, “monocultures of knowledge”, whereby the modern world utilises the formal, instrumental and economic rationality as a tool to dominate, control, the “efficiency” and mercantilisation of the world. That implies engaging in wisdom dialogues that recognise, reivindicate and value autoctonous, local or tranditional knowledge (Leff, 2007) to catalyse the best outcomes to regenerate soil health. In this way, the knowledge co-production processes enact more equitable and collaborative knowledge development. Another important factor to take into account is the adaptation of the methodologies and processes to the needs and capabilities of the community and researchers being sensitive to the local political contexts. Furthermore, the analysis also reveals potential challenges which can arise, such as the current short-term project-based science approach which is at odds with the needs of an agroecological transition (Pimbert et al., 2017). Similar to other research, short-termism is found to be detrimental to participatory approaches, as these require long-term relationships of trust (and reciprocity) between farmers and researcher-activists (Holt-Giménez, 2002; Méndez et al., 2017; Sacher et al., 2021). The case studies also revealed that culture can be an important barrier for successful application of certain participatory methodologies.

This research makes a valuable contribution to the existing literature on soil health, agroecology, and participatory knowledge co-production. It extends the discourse by shedding light on the transformative potential of participatory approaches within agroecological networks, showcasing how the integration of indigenous wisdom, community engagement, and scientific insights can lead to a holistic understanding of soil health. By exploring various dimensions of soil health knowledge co-production, including settings, synthesis, and diffusion, this research provides a nuanced perspective on the multifaceted nature of participatory processes within agroecological networks. Additionally, this study underscores the adaptability of knowledge co-production strategies to local contexts and highlights the potential of an agroecological transition not only to enhance soil health but also to empower communities, particularly women, and challenge existing power structures. It also underscores the importance of ancestral, indigenous, and traditional knowledge in soil regeneration, advocating for its conservation and recognition within the agroecological movement. Overall, this research offers fresh insights and practical implications for researchers, policymakers, and practitioners seeking to advance the agroecological transition.

Future research

Soil research has been underfunded and soil itself has been undervalued. Raising awareness about the importance of the soil is essential, but awareness alone is not enough: actions are required to undo the damage that has been done in a timely manner, as failure to act now will result in more severe losses of living soil as it is a non-renewable resource. This is why understanding cases like Rete Humus and Navdanya narrate stories of action and processes of empowerment which elucidate ways and practices to inspire us to find and start our own processes of transformation in our food systems and in society as a whole. While structural barriers exist, collective action and organisation can take us further and closer to networks and social movements that create the new regenerative structures needed to really address the sustainability challenge of healing our soils.

As many other researchers have already pointed out (Sacher et al., 2021; Utter, A, et al. 2021), there is a significant research gap in understanding the specific contexts and perspectives that allow the implementation of an agroecological transition across geographical scales, both in terms of the research on agroecology as well as for participatory knowledge co-creation processes. This type of research requires an environment in which more democratic decision making approaches are fostered (Pimbert, 2017), which facilitate the development of long-term visions and collective action. Allowing for the creation of processes and spaces where agroecological research can take place and in which food systems transformation can be catalysed in the long run.

Further research should continue studying the emancipatory processes of knowledge co-production in soil health within agroecological networks across different geographical areas and scales. Knowledge co-production processes for soil health knowledge co-production can generate usable knowledge for soil health regeneration. These processes require a careful and transparent design with clear goals and adaptable procedures in order to produce knowledge outputs which meet the needs of the intended decision makers.

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Annexes

Annex 1: Research interview guide for Navdanya and Rete Humus

1. Soil tests introduction
    1.1. What is the rationale for Humus' participatory soil tests?
    1.2. What is the method used?
    1.3. Why was this method chosen?
    1.4. What are the (main) results of Navdanya's' soil tests?

2. Can we create a SWOT on this method drawing from both the field experience and the laboratory/university analysis?

3. Knowledge co-production elements
    3.1. Who are the actors involved in the process?
    3.2. What are the factors shaping the co-creation process and outcomes?
    3.3. What is the motivation for farmer and citizen engagement?
    3.4. What are the power dynamics you can observe in the process?
    3.5. How can this method encourage peasants in the Navdanya network to have a "voice" that can be heard at the social and political levels?

4. Are there any present and future plans/opportunities for me to join/observe/document the fieldwork?

Annex 2: Research interview guide for ENOLL

1. Are there any Soil Living Labs (SLL) and Lighthouses focusing on the agroecological transition?
   1.1. If yes, could you specify which? Would it be possible to obtain a contact to reach out to them?
   1.2. What are the transformative potential and pathways for change that can be facilitated by a soil monitoring framework informed by citizen science and agroecological initiatives?

2. Are there any robust citizen science approaches to monitoring soil health within the Living Labs and Lighthouses? If so, which ones?

Setting

3. What are the drivers and barriers you have observed for the engagement of each key stakeholder[8] in SLL and Lighthouses?
4. What soil data/information needs do different users have and what barriers do they perceive to accessing and using soil data/information?

Synthesis: Knowledge creation process

5. How do power dynamics and social inequalities shape access to information, decision-making processes, and the distribution of benefits and risks in SLL and Lighthouses?
6. How can a soil monitoring framework integrate diverse forms of knowledge, including indigenous and local knowledge systems, to capture the complexity of soil health and promote more emancipatory, inclusive and context-specific monitoring approaches?

Diffusion:

Knowledge outputs and outcomes

7. Are soil datasets from citizen science projects of sufficient quantity and quality to be used in EU decision making?

Usability of the produced knowledge

8. How can citizens and farmers effectively contribute to shaping the national and EU monitoring framework for soils?
9. What strategies and mechanisms can be employed within SLL & Light houses to empower marginalised communities and ensure their meaningful participation in decision-making processes?

[8] Stakeholders stated in "Couture, Isabelle, & Grbović, Vladislava. (2023, June 22). Living Lab Essentials & How to set up a Living Lab. Zenodo. https://doi.org/10.5281/zenodo.8073797": Academia, industry, citizens and government.

10. What are the feedback mechanisms to ensure fit-for-purpose knowledge co-production in SLL and Lighthouses?