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Research Article

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Soil Stakeholders' Perspectives on Improving Soil Health and Sustainability

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ABSTRACT
The first Living Laboratory (LL) workshop (WS1) was held at Cukurova University in Adana, as part of the European Union-supported SUS-SOIL project. The main aim of the LL WS1 was to raise public awareness of the ecosystem services provided by soil and to promote soil health through agroecological approaches. The event was attended by 56 participants, representing academia (54.4%), farmers (22.8%), the public sector (19.3%), industry (3.5%), and students. The participants were 65% male and 35% female. The surveys were conducted among WS1 participants to assess their awareness of soil health and sustainable agriculture, their user needs, and business models for farmers and landowners. Additionally, a feedback survey gathered participants' opinions on the effectiveness of the workshop.
Participants ranked soil health-related issues in the following order of importance: erosion, climate change impacts, and declining soil biodiversity. Among the main causes of soil degradation, cultivation was identified as the most significant risk factor, followed by the conversion of natural areas into agricultural land. The most important goals identified by participants included reducing desertification, improving soil structure, and preserving soil organic carbon. Furthermore, participants noted that the Living Soil Laboratory contributed significantly to fostering a culture of information sharing and joint decision-making. In a survey on soil health databases and information platforms, most participants reported being previously unfamiliar with platforms such as EU-Farm Book. Nevertheless, there was a strong interest in using digital platforms. Participants particularly preferred keyword search and filtering techniques for accessing these platforms. Regarding expectations for the Decision Support System (DSS), participants highlighted the need for region-specific fertilization guides, crop rotation strategies, and risk analyses. The greatest challenge noted was interpreting the results. Post-workshop feedback indicated high satisfaction. Ninety per cent of participants found the workshop duration appropriate, 80% considered the content relevant, and 70% rated the organisation as successful. Survey results indicate that farmers and producers are sensitive to soil health and sustainability, and emphasise that in-situ soil conservation is essential for addressing future climate change challenges.
Keywords: Soil health, sustainability, climate change, human effects, ecological survey

INTRODUCTION

Changing, evolving, and developing world conditions, along with the rapid growth of the world's population, have led to an increasing need for food and raw materials. Unsustainable land use, driven by increasing population pressure, changing consumption habits, and extreme weather events, is causing widespread soil degradation and loss not only in Europe but also globally (ESDAC, 2025). With the increase in agricultural and industrial activities, identifying and implementing preventive and restorative agroecological measures to protect soil health has become vital for global sustainability. One of these activities is the Living Laboratory movement, whose official birthdate is generally accepted as 2006. This year, the European Commission officially announced its support for projects to advance, coordinate, and promote a standard European innovation system based on LL (Dutilleul et al., 2010). In recent years, the LL phenomenon has been embraced in our country and has inspired many activities. EU Soil burro wants to establish 100 LL throughout the EU geography. A Living Laboratory is a physical or virtual space used to solve social problems, particularly in urban areas, by bringing together diverse stakeholders for collaboration and collective idea generation (Hossain et al., 2019). Through connections established between soil science, policy, and stakeholders, LL can serve as real-world collaborative innovation hubs and can be used to reverse the course of soil degradation, maintain soil health, and ultimately restore degraded soils (Taskin et al., 2025).
By connecting stakeholders from diverse segments of the community, LL within the regional framework increase the potential for technological innovation and for promoting a digital culture (Zavratnik et al., 2019). In addition to technological outcomes, LL have been successful in promoting inclusive local development

among all stakeholders through collective learning, co-creation of innovation, and knowledge exchange (Habiyaremye, 2020). Agroecosystem Agricultural Practices are defined as interdisciplinary approaches that bring together farmers, scientists, and other relevant partners to jointly design, monitor, and evaluate new and existing agricultural practices and technologies to increase their effectiveness and early adoption in their study areas (McPhee et al., 2021). However, LL activities, particularly those related to regenerative agriculture and/or soil health maintenance, appear to be limited. One study revealed that only approximately 3% of the more than 3,000 studies on ALAs published in the last 12 years addressed soil (Taskin et al., 2025). It is now imperative to increase soil health research and raise awareness on the topic. As soils are the most significant terrestrial carbon sink on earth, their role in carbon sequestration and climate change mitigation is significant (Neher et al., 2022).

In this context, our 1st Living Laboratory workshop, which we held with stakeholder participation from different disciplines, was organized to serve this purpose, and participants' current ideas and knowledge about soil health and sustainability were collected through surveys.

MATERIALS AND METHODS

Preparation for the 1st Workshop on the Living Laboratory (LLs) for SUSSOIL

The first Living Laboratory (LL) workshop (WS1) was held on 28 February 2025 at Cukurova University in Adana, as part of the European Union-supported SUS-SOIL project. Surveys were conducted with representatives from academia, the public sector, producers and industry in order to increase the effectiveness of the workshop.

Surveys

Four different surveys were conducted during the living laboratory workshop. These surveys were determined as user needs (25 questions), Business Model (6 questions), soil health (10 questions) and post-workshop feedback (14 questions). The surveys were created according to the structural survey methodology. Once the purpose and scope of the workshop had been clearly defined, the organization process was initiated and tasks were assigned to the relevant team members. First, stakeholders identified at previous meetings were sent an invitation letter prior to the workshop and were asked to complete a participant information form and provided with information about the workshop to ensure their participation in accordance with WS1 requirements. In addition, the materials to be used before, during and after the workshop were prepared and delivered according to the defined schedule. The surveys included in these materials were administered to the relevant stakeholders by the responsible colleagues, either manually or via an application.

The survey results were analyzed by entering the data into separate excel tables created for each question. In addition, the results were also organized graphically for more effective interpretation.

RESULTS AND DISCUSSION

Actors and their proportion

The participants are divided into four main sectors, and their total numbers and percentages are shown in Figure 1. The total number of participants in all categories is 56. Academia is the largest group with 31 participants, accounting for approximately 54.4% of the total. This shows that education and research institutions are intensely involved in the topic or activity.

The second largest category is the landowner and farmer category, accounting for approximately 22.8% of the total, with 13 participants. This shows that the general public and land stakeholders have a significant level of interest and participation in the topic. The government and public sector category includes 11 participants, accounting for 19.3% of the total.

Finally, the industry category is the least represented, with only 2 participants, accounting for 3.5% of the total. This shows limited direct participation from the private sector or commercial stakeholders. In terms of gender balance, participation is skewed towards men. 65% of all participants are male and 35% are female. Participation in the workshop was high from the academic field, with 38.7% of participants being women and 61.3% being men. This situation has an impact on the gender distribution within the overall participation and results in more female stakeholders being added to the next workshop. This suggests a gender imbalance that needs to be addressed in future activities or initiatives to ensure more inclusive representation. Overall, the data reflects a diverse but unbalanced representation across sectors and genders. Academic and male participants are the majority. This distribution may influence the perspectives and priorities expressed in discussions and conclusions and should be considered in interpreting the findings and in future planning.

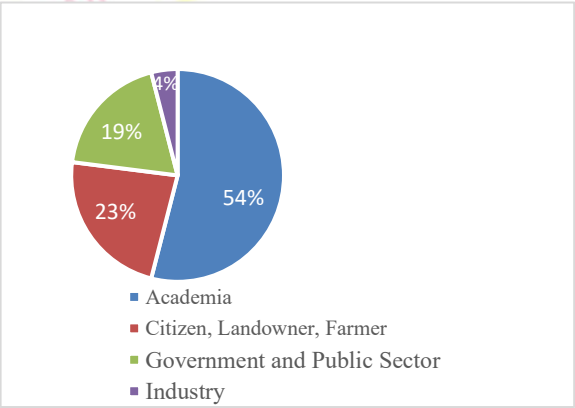

Figure 1. WS1 stakeholders and proportions

Soil Health Challenges

Stakeholders and other participants were informed about soil erosion and the effects of climate change as serious problems in the Çukurova Region of Turkey.

Stakeholders' attention to soil erosion may stem from the low organic matter content of soils in the Cukurova region. Stakeholders may have wanted to emphasize the importance of incorporating organic fertilizers and plant waste into the region's soils to address this problem. One study found that organic fertilizers and plant waste improve soil structure, increase soil water retention, and reduce soil erosion(Demir et al., 2003). In addition, participants identified decreasing soil biodiversity as the third soil health issue. The decline in biodiversity is believed to be associated with the limited product range and extensive agricultural spraying in the region. In recent years, seasonal climatic conditions, such as excessive rainfall, frost risks, and droughts, have severely impacted production and soil health in the area. It is thought that this situation has also led to increased erosion and biodiversity loss. The burning of crop residues, one of the most critical problems in the region, negatively affects soil biodiversity, disrupts the soil ecosystem and nutrient cycle, reduces soil fertility, and endangers ecosystem resilience, leading to long-term soil degradation (Pradhan et al., 2024).

Results show that soil pollution is less important than other parameters in the region. It was determined that many participants shared the view that compaction and weak soil structure could also be problems due to the region's texture (Figure 2).

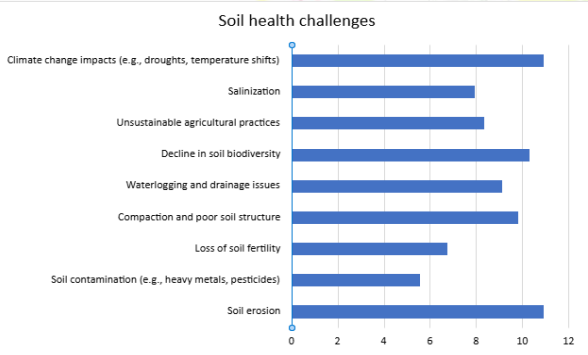

Figure 2. Ranking of health issues voted on by CU SUSSOIL LL stakeholders

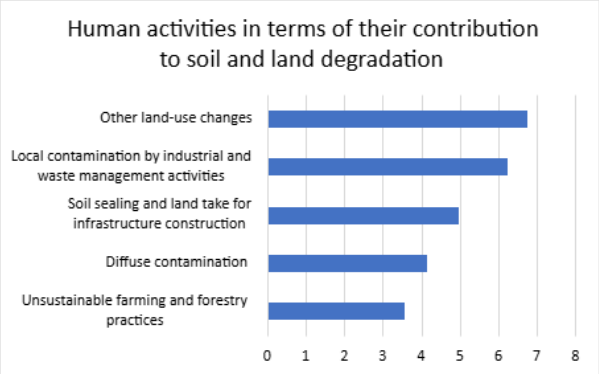

Figure 3. Ranking of human activities that contribute most to land degradation by CU LL stakeholders

Land Degradation Due to Human Activities

Land degradation is a serious threat that has no limits and can reduce the capacity of soil to provide ecosystem services. (Smiraglia et al., 2016). Participants think that the most crucial cause of human-induced soil degradation is the conversion of natural areas, wetlands, and forests into arable land. The fact that the participants, the majority of whom are from academia and landowners/producers, focus on this issue in particular underscores the importance of examining it for the region. A study conducted in Western Anatolia between 1990 and 2005 found that forest areas decreased by 17% while agricultural land increased by 5.71%. This was attributed to the conversion of forest areas first to maquis and then to agricultural lands. (Cukur, 2014). In addition, stakeholders rank the impact of local pollution from industrial and waste management activities as the second most crucial factor in the land degradation process. As agroecological production models spread and consumer awareness grows, it has become inevitable that industrial pollution comes to the fore. The region's unsustainable agricultural and forestry practices have been selected as the parameter that causes the least soil degradation among human activities. The reason may be that local people, who produce using traditional methods, do not perceive this parameter as a cause of degradation (Figure 3).

According to a model developed in a study on land degradation and development in China between 1985 and 2015, human activities (58%) are the dominant driver of land degradation and development, compared to climate change (0.34%) (Kang et al., 2021).

Key Elements for Achieving the EU Soil Mission Objectives

According to the survey results, reducing desertification is essential for farmers in Turkey to achieve the EU soil mission targets. This is followed by improving soil structure and biodiversity, and preserving and increasing soil organic carbon. The fact that the first parameter that comes to mind in this ranking is desertification may be due to its connection to the decline in soil fertility. Therefore, food production decreases. Since soil fertility is perceived as a gain by producers, it is imperative to consider protecting soil organic carbon stocks alongside improvements in soil structure and increased biodiversity (Figure 4).

The "European Soil Mission," as it is known, addresses the negative consequences for a range of essential ecosystem services arising from deteriorating soil health. The mission is based on a well-established and coherent strategy that goes far beyond what can be achieved through Horizon Europe's research and innovation actions alone (Janssen and Schiele, 2023).

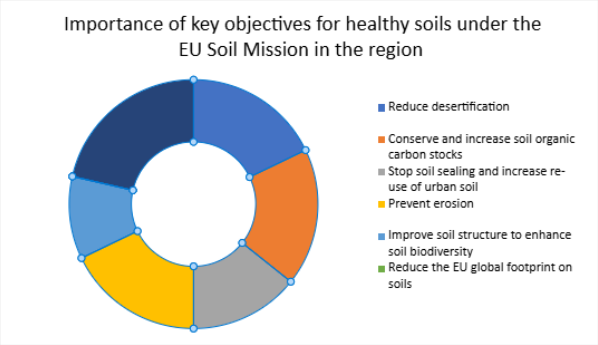

Figure 4. The most critical targets for healthy soils for Turkey's soils, according to the priorities set by the EU Soil Mission

The Benefits of Joining a Live Laboratory

Participants identified collaboration with different segments and disciplines of society as the most important benefit of participating in the living laboratory. This situation may indicate that we need more organizations to support cooperation and communication in problem-solving across our country and region. The participants identified opportunities to create solutions together and to renew them as the second significant benefit of the living laboratory. As in every field, Turkish farmers also believe that LL activities will be beneficial for establishing a common decision-making mechanism on a given subject and for implementing innovative ideas. Contributing to sustainable development and social impact was found to be as important as renewing and producing standard solutions. Since most participants evaluated these two parameters as a whole and saw them as interconnected, it can be inferred that discussing them together will benefit development and, therefore, economic growth. Among the benefits of the LL, improved skills and knowledge, impact on policy and decision-making processes, and a better understanding of real-world challenges and context were considered unimportant compared to other parameters (Figure 5).

Focusing on local testbeds (100 LL and lighthouses through the EU), monitoring, education, and engagement activities represent a promising way to engage stakeholders, facilitate experiments, and disseminate learning. These activities also lay the foundation for a range of complementary research and innovation activities by both public and private actors. Therefore, enhanced multi-level governance (including national, regional, and local stakeholders) remains a medium- to long-term necessity to maximize the mission's impact. (Janssen and Schiele, 2023).

The use case of information sharing on EU platforms

Digitalization in agriculture is a term frequently encountered, particularly in Europe. The EU Digital Strategy encourages the use of digital solutions to improve data management and decision-making across various economic sectors (European Commission, 2022).

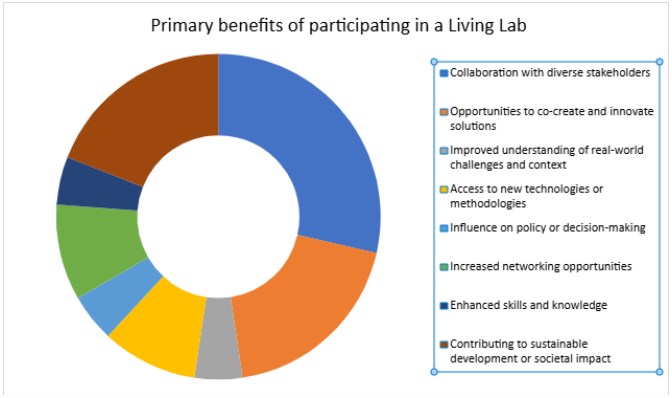

Figure 5. Benefits of joining LL as evaluated by stakeholders in Turkiye

According to the graph, most participants were not aware of information-sharing platforms such as EU-Farm Book. This shows that most representatives from the academy, who had the highest number of participants, did not know about or use these platforms. The widespread use of digital literacy and the need to increase university access to such platforms are essential. The EU Digital Strategy promotes the use of digital solutions to improve data management and decision-making across sectors of the economy (European Commission, 2022). Furthermore, the Common Agricultural Policy 2023-27 emphasises the integration of digital technologies to improve agricultural practices (European Court of Auditors, 2022). However, digitalization is not merely a technical process; it is also, a socio-political transformation that restructures knowledge, labour, and power in agriculture (Velden et al., 2024).

Ease of Use of Digital Platforms for Soils

The graph shows that most participants feel very comfortable and relaxed when using these digital platforms. Conversely, some participants appear undecided about the use of digital platforms. The most significant conclusion derived from this graph is that participants do not feel uncomfortable or very uncomfortable when accessing digital platforms for soil research. This scenario underscores the potential desire and preference to access and utilize both existing and new platforms when seeking information. (Figure 6).

Business models

The following are the results of the Decision Support Tool for SUS-SOIL Management:

Expectations from the DSS tool

Information on region-specific soil management practices and fertilizer application guidelines is expected to be suggested by the Decision Support System (DSS) tool. It was observed that some participants needed information on crop selection, rotation strategies, and

risk assessment. Information on the level of policy compliance was not very important (Figure 7).

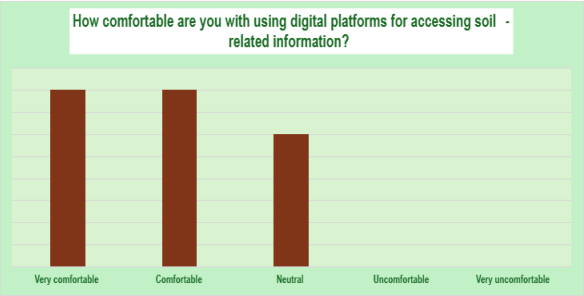

Figure 6. Tolerance level of CU-LL participants towards the use of digital platforms for sharing information

Figure 7. Types of recommendations are expected under CU LL.

Expected Difficulties When Using the DSS tool

As shown in Figure 8, the most significant challenge for our workshop participants was interpreting the results. Because it is quite normal for participants without sufficient knowledge of the subject to choose this parameter in the first workshop and the living laboratory activity. This is followed by data entry requirements, a lack of integration with local/regional data, and an understanding of the interface. A small number of participants think they may encounter difficulties beyond the options mentioned.

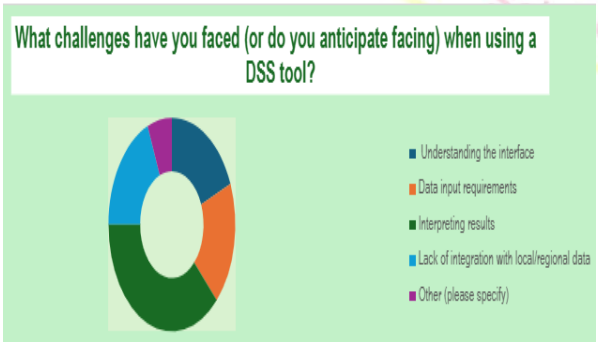

Figure 8. Challenges that CU-LL members are expected to encounter when using a DSS tool.

Preliminary Farm and Land Use Survey

When the farm and land use distribution in the Business Model Survey is examined. It is evident that eight of the participants who completed the survey are agricultural land users. The largest agricultural land owned by the producers participating in the study was 30 hectares, while the least was 3 hectares. It is seen that most of the land is used for field agriculture, while a tiny part is used for gardening, agriculture, and animal husbandry. Among the difficulties encountered in soil and subsoil, water management problems rank highest, followed by compaction, nutrient depletion, poor subsoil structure, and soil pollution. The most common parameter among economic and administrative difficulties is high input costs and low product prices. A labour shortage follows this.

Post-Meeting Activities (Feedback Survey)

The feedback survey was delivered to the participants by hand or e-mail after the workshop. In general, despite the small number of participants (10 people), we received a positive response. The majority of participants, who were academic representatives, were satisfied with meeting expectations, networking, the venue and location, the speakers, and their knowledge. When the workshop's quality was examined, 70% of participants rated the organization as good, 20% as excellent, and 10% as average. Of the participants who evaluated the event content, 80% rated it as good and 20% rated it as excellent. The intensity of workshop participation was rated as good by 60% of participants and excellent by 40%. The time allocated to the workshop was found appropriate by 90% of the participants.

Some of the feedback received from participants, apart from the survey results, included guidance to focus more on implementation and problem-solving for other workshops and living laboratory activities we plan to organize.

CONCLUSION

The first LL workshop organised by Cukurova University was successfully completed. We managed to complete the workshop on time, fulfilling all the specified requirements. During the meeting and fieldwork, stakeholders and participants gained knowledge about what surface and subsoil are, how they should be protected, and how innovative ideas, information, and experiences can be transferred to traditional producers. In addition, the participants' focus on climate change and erosion issues specific to the region for soil health has shed light on future LL projects. It was also concluded that stakeholders would focus on the impact of human activities on soil degradation in other workshops to be held in order to generate solutions. While stakeholders agreed on the continuation of such LL workshops, it was decided that it would be important to examine the issue within the framework of the European Soil Mission. The idea of making digital platforms available primarily to local farmers and other stakeholders attracted interest, but it was decided to elaborate on the issue at the second workshop. Due to the limited sample size and the small number of stakeholders participating in the project's first workshop, the workshop survey results are exploratory in nature rather than representative of all land stakeholders in Turkey.

CONFLICT OF INTEREST

The author here declares there is no conflict of interest in the publication of this article.

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