

Bridging Soil Science and Society: The Role of Community-engaged Learning in Advancing Soil Health Governance

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Abstract—Growing recognition of the importance of soil degradation as a critical environmental, economic, and societal challenge requires new approaches to governance that combine scientific knowledge with public decision-making. This article explains the involvement of Ss. Cyril and Methodius University in Trnava (UCM) in the Horizon Europe LOESS project and highlights the political significance of the educational initiative Education for Soil Health: Community-Based Research and Learning (CERL). The article, which interdisciplinarily links the fields of education policy, good governance, and environmental management, demonstrates how community-engaged research and education can strengthen evidence-based soil health policies that respond to societal needs. The CERL-based training module is an innovative capacity-building tool that equips students, researchers, and stakeholders with the skills needed to co-create knowledge with local communities, public authorities, and civil society actors. By promoting participatory research practices, this form of education helps translate scientific knowledge into locally rooted and socially legitimate policy solutions. Based on UCM's experience with integrating CERL principles into higher education and stakeholder collaboration, the article argues that such approaches enhance the quality, inclusiveness, and feasibility of public policies related to soil protection and sustainable land use. Attention is paid to the role of universities as intermediaries between science, policy, and communities, and to the implications for multi-level governance within the European Green Deal and the European Union (EU) Soil Strategy. The paper concludes that community-engaged learning is not only an educational innovation but also a strategic governance instrument that contributes to more targeted, participatory, and effective public policy design and implementation in the field of soil health.

Keywords—soil science, society, community-engaged learning, soil health governance, public policy

I. INTRODUCTION

Soil health has become a core priority of European research and policy due to its essential role in ecosystem functioning, food security, climate mitigation, and biodiversity preservation. Healthy soils underpin the delivery of key ecosystem services, from nutrient cycling and water regulation to carbon sequestration, yet more than 60% of soils across the European Union (EU) are currently classified as unhealthy, largely due to erosion, contamination, sealing, and unsustainable land use practices. Addressing soil degradation is essential for achieving the environmental and societal objectives of the European Green Deal, including climate neutrality, biodiversity protection, sustainable food systems, and the EU Zero Pollution Ambition [1].

The EU Soil Strategy for 2030 [2] provides an overarching framework for soil protection, restoration and sustainable use, with the aspirational goal that all soils in the EU are in good condition by 2050. It emphasises the need for integrated soil monitoring, enhanced scientific knowledge and stronger governance mechanisms across member states.

To operationalise these strategic goals, the European Union has adopted the Soil Monitoring and Resilience Directive [3], the first dedicated EU law aimed at creating a coherent framework for assessing, monitoring and enhancing soil health across different land uses. The directive requires member states to establish systematic soil monitoring systems, report on soil health indicators and strengthen resilience against key threats such as contamination and loss of organic matter. It also embeds principles for land-take mitigation and supports sustainable soil management practices through common methodologies and shared tools.

Within this evolving policy landscape, the Horizon Europe Literacy boost through an Operational Educational Ecosystem of Societal actors on Soil health (LOESS) project, funded by the European Commission, advances soil health not only through research but also through education. A central component of LOESS is the Education for Soil Health: Online Training Module on Community-Engaged Research and Learning (CERL), which aims to enhance soil literacy by fostering collaboration among researchers, educators, local communities and policymakers. By positioning community-engaged learning at the heart of soil education, the module contributes to participatory approaches that can inform and strengthen both local and EU-level soil governance frameworks.

The University of Ss. Cyril and Methodius in Trnava (UCM) actively participates in LOESS, bringing together multidisciplinary expertise in public policy, public administration, and environmental governance. This paper explores how the integration of CERL principles into higher education and stakeholder engagement helps bridge scientific research with policy and practice, offering insights into how universities can support more targeted, inclusive and evidence-informed public policies in the domain of soil health.

II. METHODOLOGICAL FRAMEWORK

This study applies a qualitative, multi-method research design combining policy analysis, case study research, and elements of educational evaluation. The objective is to examine how Community-Engaged Research and Learning

(CERL), implemented through the LOESS educational framework at the University of Ss. Cyril and Methodius in Trnava (UCM), contributes to more targeted and socially responsive soil health governance.

A. Policy and Document Analysis

The first component consists of a structured analysis of key European and national policy documents related to soil protection and environmental governance. These include the EU Soil Strategy for 2030, the Soil Monitoring and Resilience Directive, and relevant national policy frameworks. The analysis focuses on identifying governance gaps related to stakeholder participation, knowledge transfer, and implementation capacity. LOESS project materials and the CERL training module content are examined to assess their alignment with these policy needs and governance priorities.

B. Case Study Approach

UCM's participation in the Horizon Europe LOESS project serves as an in-depth case study illustrating how higher education institutions can act as intermediaries between science, communities, and public authorities. The case study documents:

- The integration of CERL principles into teaching and research activities [4],
- Cooperation with local stakeholders (e.g., municipalities, civil society, land users) [5, 6],
- The ways in which community-engaged learning activities generate policy-relevant knowledge.

Data sources include project reports, course materials, stakeholder workshop outputs, and institutional strategy documents.

C. Stakeholder Perspectives

To understand the governance relevance of CERL, qualitative data are collected from participants involved in the educational and engagement activities (Communities of Practice (CoP)). These may include students, educators, local stakeholders, and public administration representatives. Data collection methods through CoPs [7, 8] represent involvement of groups of individuals (focus groups) who share a concern, a set of problems, or a passion about a topic, in this case, soil health, and who deepen their knowledge and expertise by interacting regularly. Unlike formal teams, CoPs are informal, self-organising, and learning-oriented networks that span disciplines, sectors, and levels of governance. The analysis explores how participants perceive the usefulness of CERL for understanding soil health challenges, facilitating dialogue, and informing public decision-making.

In professional literature, the concept of communities of practice is presented as a framework for learning and mobilizing knowledge that transcends professional, organizational, and political boundaries. This alignment reflects broader European discussions on communities of knowledge that link practice and policy, emphasizing concepts such as social learning, legitimacy, and distributed leadership as key components that involve member engagement and shared meaning.

D. Analytical Framework

The empirical material is analysed using a governance-oriented framework drawing on concepts of:

- participatory governance,
- knowledge co-creation,
- and science-policy interfaces.

This framework enables the assessment of how CERL contributes to bridging gaps between scientific knowledge, community experience, and public policy processes. Particular attention is paid to whether the approach enhances policy relevance, legitimacy, and implementation potential in soil health governance.

E. Limitations

As a single-case, context-embedded study, the findings are not statistically generalisable. However, the research provides analytically transferable insights into how community-engaged higher education can function as a governance innovation supporting the objectives of EU soil policy.

III. THE NEED AND PATH TO RAISE THE LEVEL OF SOIL LITERACY

Soils are a fundamental natural resource, providing ecosystem services that sustain agriculture, water regulation, biodiversity, and climate resilience. Among these, loess-derived soils are particularly significant in Central Europe, including Slovakia. These soils are highly fertile, well-drained, and capable of supporting intensive agriculture, which makes them central to regional food production, rural livelihoods, and the economic stability of local communities. In addition to their agricultural value, loess landscapes carry cultural and historical importance, shaping settlement patterns, traditional land-use practices, and local identity. Despite their high fertility, loess soils are highly susceptible to erosion, compaction, and degradation under unsustainable land-use practices. Modern challenges such as climate change, urban expansion, and intensive farming exacerbate these vulnerabilities. In this context, raising soil literacy, the knowledge and awareness of soil properties, functions, and sustainable management, is essential. Improving soil literacy allows farmers, local decision-makers, educators, and the wider public to make informed decisions that safeguard soil health while supporting socio-economic development [9].

Solving complex social problems therefore currently requires new models of cooperation and knowledge acquisition and utilization. Traditional hierarchical approaches are gradually being replaced by participatory and collaborative forms of governance that emphasize the involvement of actors in all phases of the political cycle. One of the most effective tools of this type are so-called "communities of practice" [7, 8] defined as autonomous, long-term groups of people united by a common issue, need, or professional practice. In the field of education policy, CoPs can serve as platforms for connecting educators, researchers, practitioners, non-governmental organizations, and public institutions. Their importance is growing, especially for topics that require an interdisciplinary approach, innovation in education, and active community involvement. One such topic is soil literacy, which is the focus of the LOESS project funded under the Horizon Europe

program. The aim of this article is to show how CoPs work in the LOESS project and what lessons they offer for education policymaking. The analysis is based on project documentation, conceptual frameworks for participatory policymaking, and CoP theory.

Importantly, by situating soil education within participatory, community-engaged frameworks, the LOESS project contributes to advancing soil health governance in several ways. Firstly, it helps overcome the awareness gap that often isolates soil science from public and policy discourse, making soil functions more visible and relevant to everyday decisions about land use, agriculture and environmental stewardship. Secondly, it builds capacities for multi stakeholder collaboration, enabling communities to engage meaningfully with policymakers, educators and researchers in co designing local land management strategies. Thirdly, by embedding soil literacy within formal and informal learning ecosystems, the project supports the development of socially grounded and ecologically informed governance paradigms that are responsive to both local realities and broader sustainability goals [10].

Community Engaged Learning (CEL) is an educational approach that directly connects learners, scientists, policymakers, and local communities through active, participatory learning activities. In the context of soil health, CEL serves as a bridge between scientific knowledge production and societal action in several interrelated ways:

A. Translating Science into Practice

CEL allows scientific findings about soil properties, fertility, erosion risks, and sustainable management practices to be communicated in accessible, context-specific ways to local stakeholders. Instead of knowledge remaining in academic publications, it is transformed into practical insights for farmers, educators, municipal planners, and civil society organizations. This translation helps stakeholders understand the relevance of soil science to everyday land use and decision-making.

B. Participatory Knowledge Co-production

Through CEL, local knowledge, traditional practices, and community observations are integrated with formal scientific research. This co-production of knowledge ensures that soil governance strategies are grounded in both empirical evidence and local realities. Involving communities in data collection, monitoring, and problem-solving builds a shared understanding of soil health challenges and potential solutions.

C. Fostering Informed and Inclusive Decision-making

By actively involving citizens, CEL increases awareness and accountability in soil management. Communities develop a sense of ownership over local soil-related issues, which enhances compliance with sustainable practices, policy initiatives, and conservation programs. Inclusive participation also ensures that marginalized groups have a voice in decisions affecting their local environment.

D. Creating a Culture of Environmental Stewardship

CEL initiatives promote and significantly increase civic engagement and environmental literacy. Participants gain not only knowledge, but also critical thinking skills,

opportunities for discussion, problem-solving abilities, and motivation to act in ways that protect soil resources. This creates social feedback: informed citizens promote sustainable policies, which in turn reinforce scientific research priorities and public policy frameworks.

E. Strengthening Governance Mechanisms

By linking research, education, and community activities, CEL also strongly supports adaptive, evidence-based, and socially legitimate governance. Policies and relevant strategies developed through this approach are more likely to be better accepted, effective, and resilient because they are based on scientific knowledge and the experience of local communities.

IV. CONCLUSION

The LOESS project shows that CoPs and CERE are suitable mechanisms for complex educational innovation. The transformation of education policy towards sustainability requires the involvement of various actors with different knowledge and experience. CoPs provide a space for joint experimentation, learning, and adaptation of policy solutions. From a public policy perspective, they bring two key elements: professional quality, based on a combination of scientific and practical knowledge, and social legitimacy, which is essential for successful implementation. Based on the analysis of the LOESS project, several recommendations for the development of education policies can be formulated. It is important not to give up on efforts to continue systematically integrating communities of practice into the development of education strategies at both the regional and national levels. It is also necessary to institutionalize participation in this area in the form of permanent networks of experts, educators, and community actors. It is also necessary to strengthen the database of educational policies through local analyses organized within the CoP and to ensure the long-term sustainability of the CoP even after the end of the project implementation. At the same time, however, it is possible to consider the possibility of continuing to use pilot environments at the local community level as laboratories for testing innovations before their nationwide implementation. Based on the analyses carried out, we have come to the conclusion that the implementation of national and regional policies is focused almost exclusively on the area of description and regulation. The area of description and the procedural aspects of land use are also part of the school curriculum. There is an almost complete absence of soil literacy policies focused on the impact of healthy soil on citizens' health. The ongoing EU project—the Loess project—therefore has great potential to fill this gap. However, it should be added that even if the Loess project is successful, legislators will need to be receptive to implementing the resulting outputs into public policies. The LOESS project itself represents a model that can be transferred to other areas of education policy, from environmental issues to digital skills and civic participation.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

A.Č. developed research ideas and concept and wrote a preliminary script; A.Č. and M.K. developed methodology and provided research documentation; A.Č. and M.K. managed and organized data; and K.S.N. contributed to data interpretation and manuscript review. All authors discussed research results and findings and had approved the final version.

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