LOESS

LITERACY BOOST THROUGH AN OPERATIONAL EDUCATIONAL ECOSYSTEM OF SOCIETAL ACTORS ON SOIL HEALTH

WP2 - EXPLORING SOIL AWARENESS, CONTENT GAPS, TEACHING NEEDS AND EDUCATIONAL VISIONS

D2.2 – Report on awareness, needs and vision for soil education

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	Work package leader AMU	**Deliverable description** This deliverable presents the current state and aspirations for soil education, identifying content deficits, educational needs, practical barriers, and enabling factors based on desk research, focus groups, interviews and questionnaires in 15 countries, and a survey across Europe.
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Report on Awareness, Needs and Vision for Soil Education

This report is currently under review by the European Commission, pending approval.

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1. Executive Summary

This 'Report on Awareness, Needs, and Vision for Soil Education' summarizes the findings of a research conducted under LOESS project (Work Package 2) within the EU Mission, 'A Soil Deal for Europe' (**hereinafter referred to as EU Mission Soil**). This research consisted of two studies.

The **first study** explored soil (health) educational design. It focussed on assessing the current 'state', and on identifying the 'wishes' for soil (health) educational design at different educational levels—primary, secondary, vocational, tertiary, and general public. This first study employed a triangulated approach of desk-research, focus group and interviews across 15 European countries to specifically explore the educational design for each educational level by focusing on the following dimensions of soil (health) education: purpose (for what), collaborations (with whom), learning space (where), learning process (how), learning activities and paradigm (from what assumption/worldview). Furthermore, based on the insights gained, each of the 15 European country partners responded to a questionnaire presenting an overview of the 'state' and 'wishes' of soil (health) educational design in own country, for each of those dimensions just mentioned without differentiating educational levels. Additionally, each LOESS Community of Practice (CoP), bringing together actors and stakeholders from various disciplines and sectors related to soil education in each of the 15 European countries involved in this study, provided feedback on the first study process and outcomes. Points of contention and disagreement between CoP members and researchers are also included in this report.

The **second study** explored educators needs. This second study consisted of an online survey, conducted to explore what European educators know and teach about soil (health), identify the barriers they face, and determine their needs and attitudes towards teaching soil (health) topics. This included examining their sources of knowledge and specific topics they cover in curricula, as well as a self-assessment of their needs for soil (health) teaching.

Based on the first study (desk research, focus groups, interviews, and questionnaire), and the second study (survey), this report presents insights into shared experiences and explores key factors shaping innovative soil teaching practices. Outputs of this report will constitute the knowledge basis for the LOESS work-package 3, 'Content Definition and Implementation: Co creative development and testing of target group oriented soil education measures', in addition to other LOESS activities.

Key findings: A key finding, from both first and second studies, was the general absence of the term 'soil health' within educational offerings. Consequently, the research focused on exploring educational offerings that, although in most cases not explicitly mentioning soil health as such, they were related to and relevant for the health of the soil, according to the perceptions of those involved in the research. For this reason, in this report, we use the

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term 'soil (health)' to encompass both the specific explicit information on soil (health) and related topics such as general soil education.

The first study highlighted that current emphasis of soil (health) education is on knowledge acquisition (*knowing)*. Although to a slightly lesser extent, emphasis is also given to cultivating skills (*doing*), while the purpose of fostering a personal connection with soil (*being*) is apparently sidelined. The wished soil (health) education prioritizes learning to act responsibly towards soil (health) (*doing*) and nurturing values (*being*) alongside knowledge acquisition (*knowing)*. This shift envisions learner engagement through experiential *doing-based* activities (e.g., soil monitoring) and cultivating alternative ways of *being* and values (e.g., reflecting on caring attitudes towards soil conservation) rather than solely relying on currently prevalent *instructive* forms of knowledge transfer activities (e.g., lectures). *Doing-based* activities are often seen as an avenue for fostering not only new action skills, but also for exploring new ways of *being* and *knowing* through experiential learning. In this direction, there is also a strong consensus on shifting away from predominant *indoor* forms education (e.g., classrooms) and move towards *outdoor* settings (e.g., gardens, forests) to allow for more immersive and sensorial learning experience focused on soil (health) and more *emancipatory* processes enhancing students participation. There is a strong wish to move beyond the dominant *mechanistic paradigm* (focusing on understanding individual soil components and processes) towards an *ecological paradigm* that acknowledges the entanglement and complexity of soil (health), ecosystems and humans. The research also reveals that current *collaborations* in soil (health) education typically involve 3-5 disciplines or stakeholders including teachers and students. The wish is to expand these existing *collaborations* by including societal actors (e.g. farmers, businesses, policymakers) and more diverse perspectives and by creating learning contexts that better reflect real-world situations.

The second study further supported the findings that soil (health) education currently focuses on challenges such as soil pollution, degradation, and conservation. However, there is a wish to align the soil (health) education with all EU Mission Soil objectives, and place a greater emphasis on the relationship of soil (health) with SDGs *climate action*, and *good health and well being*.

Needs identified: To address the gaps and advance soil (health) education in the wished direction, specific micro-level (concerning immediate, practical changes at the level of individual educators and classrooms) and macro-level (concerning broader, system-wide changes influencing education policy and structure) needs were identified, drawing from both first and second studies.

At the micro-level, improving educator's training by specifically focusing on soil (health) related content as well as equipping educators with specialised pedagogical skills for *outdoor*, *doing-based*, *emancipatory* and more *ecological* systems-oriented approaches emerged as a common need across most countries and educational levels. There is also a significant need for better teaching materials on soil (health) topics as well as to allocate

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resources for supporting the wished educational design. Additionally, there is low awareness among educators about the EU Mission Soil, which in turn suggests the need for strategies to raise educators awareness about it. More projects such as LOESS can help bridging this awareness gap.

At macro-level, revision of curricula was identified as an essential aspect to strengthen soil (health) education within formal curricula as well as to align curricula with EU Mission Soil objectives and Sustainable Development Goals (SDGs). The educational goals and performance assessment criteria within the current curricula and educational framework also need to be revisited as the current dominance of knowledge based assessment does not matches with certain aspects of the educational design that are wished to be strengthened (e.g. e*mancipatory* processes, and *being-based* activities in some countries). Facilitation of transdisciplinary *collaboration*, connecting disciplines and sectors, is also needed and would require dedicated programs and funding opportunities. To facilitate such changes, (educational) policy reforms might be required.

Opportunities: Despite the challenges, several educational programs, initiatives, and courses across Europe were identified during the first study, that demonstrate implementation of innovative soil (health) education approaches that align with the wished forms of soil (health) education. These educational offers are presented online in the LOESS website as case studies (LOESS Project. , n.d.), and feature examples of *outdoor* learning, *doing-based* activities, *narrow-broad* to *broad* collaborations, and community engagement through participatory projects and *emancipatory* learning processes. These case studies can serve as an inspiration and practical references for designing soil (health) education to address the needs and wishes identified in this research.

Key conclusion

- Soil (health) topics are largely absent in the curricula.
- Education currently focuses on knowledge acquisition, and partly on cultivating hands-on skills, with little attention to fostering personal connections with soil.
- There is a strong wish to shift soil (health) education from *indoor, instructive, knowledge-based* methods to *outdoor, emancipatory*, and experiential learning.
- There is a strong wish to shift from the *mechanistic and* reductionist view of soil (health) to a more *ecological* and systems-oriented understanding of soil-ecosystems-humans.
- There is low level of awareness on EU Mission Soil amongst the educators.
- Educational offerings that demonstrate innovative soil (health) education approaches aligned with the wished forms of soil (health) education are presented in the LOESS website as case studies (LOESS Project. , n.d.).

Recommendations

- Enhance educator's training, develop innovative teaching materials, and allocate resources for *outdoor, emancipatory* and experiential learning embedded in an

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ecological paradigm, to support holistic development of learners as whole persons, balancing *doing*, *being* and *knowing*.
- Revise curricula to integrate soil (health) topics and align these with EU Mission Soil objectives and SDGs.
- Promote and support transdisciplinary collaborations by including more diverse perspectives and societal actors, and by creating learning contexts that better reflect real-world situations.
- Raise educator's awareness on the EU Mission Soil through projects such as LOESS.

2. Introduction

Soils play a crucial and multifunctional role for both human and planetary sustenance (Kopittke et al, 2023). While healthy soils are fundamental for provisions of food and water, they are also pivotal for supporting ecosystems, biodiversity, and assisting in mitigating climate change by carbon sequestration (Lal et al, 2021). However, soils are rapidly degrading worldwide, and there is little public awareness of the value of healthy soil. Recognizing this critical gap in awareness, the EU Mission Soil places an emphasis on increasing soil (health) literacy in Europe. To address this, it is imperative to engage all segments of population and begin with acknowledging the existing practices, values, and concerns individuals and communities hold regarding soil and its health. This approach aims to build a foundation for increased awareness, care, and engagement. The Horizon Europe project LOESS: '**L**iteracy boost through an **O**perational **E**ducational **E**cosystem of **S**ocietal actors on **Soil (health)**' began in June 2023 and will conclude in June 2027, under the EU Mission Soil. LOESS aspires to identify effective approaches to reorient soil education across all educational levels and enhance public understanding and appreciation of healthy soils through the development of educational offerings, continuous training programs, and skills development activities aimed at multiple stakeholders and target groups involved in soil education.

In this direction, a major initial task within the LOESS Work Package 2 (WP-2) was to assess the current state of soil (health) education and identify desired changes from the perspectives of both learners and educators. To accomplish this, LOESS embarked on this research by means of two studies. The **first study** explored soil (health) educational design. It employed a multi-pronged approach, encompassing desk research, 15 focus group conversations, 154 interviews and 15 questionnaires, in order to investigate the current design and content of soil (health) education across 15 European countries, and to identify the gaps, needs, challenges and opportunities that exist for achieving the wished soil (health) education. These activities integrated multiple forms of knowledge and drew from academic and practical expertise, as well as phronesis, a type of practical wisdom that considers ethical and moral implications in the context of soil education (Peters and Wals, 2013). Alongside, multi-disciplinary and multi-sectoral Communities of Practice (CoPs) established in each of the 15 partner countries further supported and validated the

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findings of this first study. Each CoP, bringing together stakeholders in soil education, provided continuous feedback on the first study process and findings, and provided deeper insights on the current status, future wishes, gaps, needs, challenges and opportunities for soil (health) education. The **second study** explored educators' needs. It employed an online survey, conducted across European countries to specifically assess the current knowledge and teaching practices of teachers and educators regarding soil (health) in Europe, and to identify challenges they face and their needs for integrating soil (health) topics in classrooms. This report presents a detailed account of these activities, and outcomes for both a cross-country and the individual country contexts.

3. Conceptual and Methodological approach

3.1. Conceptual background.

A main focus of this research was to gain a comprehensive understanding of the content and existing educational design concerning soil education particularly concerning soil (health) topics, future wishes, and educators needs. In this report, the term 'soil (health)' is used to encompass both the specific explicit information on soil (health) and related topics within general soil education. The research consisted of two studies.

The **first study, focusing on exploring soil (health) educational design,** employed a triangulation of desk-research, focus groups and interviews to identify the current state and wished features of soil (health) education from the perspectives of learners, educators, and stakeholders at primary, secondary, tertiary, vocational education and training (VET), and outreach to the general public in 15 partner countries. Desk-research, focus groups and interviews were guided by the following two general research questions (GRQs):

GRQ1: What is the state of soil (health) awareness education?
GRQ2: What are the wishes for future soil (health) awareness education?

This first study followed a conceptual framework which was developed partly drawing from literature discussing educational design, care ethics and educational paradigms (De la Bellacasa, 2017; Loonstra et al., 2024; Noddings, 2013; Tassone et al.2018, and Van den Akker, 2013), and partly drawing from the feedback received from LOESS-country partners. This conceptual framework, consisted of six (analytical) dimensions, and specific "*descriptors*" qualifying each (analytical) dimension. The above mentioned GRQ1 and GRQ2 were explored in terms of each of the six dimensions and related descriptors. desc Each of these six dimensions, and related descriptors for each dimensions, are briefly presented here, with a detailed elaboration provided in Tassone et al. (2023).

1. **Purpose (for what):** This dimension explored the current state and wished purpose of soil (health) education by focusing on its purpose in relation to three aspects. A first aspect concerned the alignment of soil (health) education purpose with the EU Mission soil objectives, while a second aspect concerned the alignment with the SDGs. The descriptors

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used for assessing these included all 8 EU Mission Soil objectives (European Commission, n.d.) and all 17 SDGs (United Nations, 2015). The third aspect, explored soil (health) education purpose in terms of human development. For this, the following descriptors were employed: *knowing* (when the purpose is to acquire knowledge, facts and information), *doing* (when the purpose is to develop application-oriented competencies and skills), and *being* (when the purpose is to explore, develop and nurture personal connections and values).

2. **Collaboration (with whom):** This dimension explored the current extent of and wished extent of collaborations across sectors and disciplines in soil (health) education. The three descriptors employed for exploring collaborations included: *narrow* (when stakeholders from the same sector and discipline collaborate), *narrow-broad* (when collaboration spans two or three sectors and disciplines, allowing for some transdisciplinary learning across different areas), and *broad collaborations* (when collaboration involves multiple sectors and disciplines, fostering extensive transdisciplinary learning among a diverse range of stakeholders from academia and society).

3. **Space (where):** This dimension explored the learning spaces where soil (health) education takes place, and where it is wished to take place. The two descriptors employed were *indoors* (when educational activities occur indoors, e.g. in classrooms, laboratories, indoor museums), and *outdoors* (when educational activities take place outdoors, e.g. in a garden, farm, etc).

4. **Process (how):** This dimension explored how soil (health) education is facilitated predominantly and it is wished to be facilitated, using the following two descriptors: *instructive process* (which is facilitated by transferring pre-defined knowledge and skills primarily guided by educators, books etc. in a pre-defined direction) and *emancipatory process* (which allows for learners to actively shape their own learning, and involves opportunities like peer to peer learning and project based learning)

5. **Activities (in what ways):** This dimension explores what are soil (health) education activities that predominantly take place, and are wished to take place. The three descriptors employed were: *knowing-based activities* (activities that involve knowledge development, for example lectures, critical reading, essay writing, etc.), *doing-based activities* (hands-on activities that involve actions, e.g. lab experiments, planting, communicating, etc.) and *being-based activities* (activities that involve (inter-) personal and socio-emotional aspects, e.g. contemplation, drawing, sensing, etc.).

6. **Paradigm (from what assumption):** In this case, a paradigm referred to a set of assumptions about the natural world. This dimension explored what paradigm currently shape soil (health) education and is wished to further shape soil (health) education. This dimension was explored through the following two descriptors: *mechanistic* and *ecological* (based on Loonstra et al., 2024). *Mechanistic paradigm* views nature, including soil, as a set of components that can be studied separately and predictably. This paradigm places an emphasis upon the specific components and processes studied predominantly through analytical and technical procedures. For example process based simulations to

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study soil functions and predict changes. *Ecological paradigm* views nature, including soil, as an interconnected system where biophysical and societal factors interact and shape each other. This paradigm acknowledged personal and societal relationships, behaviours, and motivations around soil (health). For instance, it involves studying soil as part of a broader system in which humans, animals, and the natural world all coexist and affect each other, e.g. , how one's personal, societal and economic contexts can shape the importance they assign to soil (health).

In order to investigate the GRQs 1 and 2, we embraced epistemological pluralism (Miller et al., 2008), and thus recognized the value of drawing from multiple forms of knowledge and contexts in order to gain a comprehensive understanding of soil (health) education. As such, this first study attempted to bring together academic knowledge, practical knowledge, and practical wisdom which Aristotele called phronesis.

Based on insights gathered from desk research, focus groups, and interviews, a comprehensive overview of the 'state of' and 'wishes for' soil (health) educational design for each country was developed. This overview, which did not differentiate between educational levels, was documented through a questionnaire (one questionnaire response per country, thus a total of 15 responses).

The **second study, exploring educators' needs,** employed an online survey specifically targeted on educators in Europe to assess their knowledge, teaching practices, and attitudes towards soil (health) education, and to understand how soil (health) education can be enhanced across different educational levels in Europe. The survey comprised questions using a mix of multiple-choice and Likert scale formats, organized into the following five categories:

1. Background Information: To collect respondents' demographics (country, age, gender, city size, and institution), educational background (highest qualification), and teaching levels.
2. Learning about soil (health): To assess the importance educators place on incorporating soil (health)-related topics in curricula, their training to teach these topics, and their familiarity with the EU Mission Soil.
3. Educator's knowledge: To evaluate the level of knowledge (from basic to advanced) that educators have on 30 soil (health)-related topics, and identify the topics needing more teaching materials and methods.
4. Educators' needs: To identify additional resources, materials, and opportunities required to teach soil (health) topics more frequently.
5. Attitudes towards soil (health): To examine respondents' attitudes towards soil (health), their engagement with field developments, participation in soil (health)-related research, personal practices like growing crops, and experiences with natural hazards and soil contamination.

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3.2. Data collection and analysis

For what concerns the **first study**, all partner countries followed a guideline to perform the first study comprising of desk-research, focus group, interviews and questionnaire within the context of their own counties. The guideline was developed by the partners at the Wageningen University and Research, Netherlands. The educational levels (primary, secondary, tertiary, vocational education and training (VET), and general public) in each country were differentiated according to the framework provided by European Commission et al. (2022).. Here, it is provided a short description of methods of data collection and analysis of this first study. Further details are presented in the guideline provided in Tassone et al. (2023).

Desk-research: The goal of the desk-research was to comprehensively study existing soil (health) education literature (education and training offers, policy documents, scientific literature, research projects and grey literature) within the LOESS partner countries at all educational levels. The specific objectives were:

- Collation and screening of soil (health) literature with a connection to Education for Sustainable Development at schools and higher education institutions.
- Evaluation of the effectiveness of these offers in addressing key aspects of national and European policies and strategies focused on soil (health).
- Identification of strengths and shortcomings of these soil (health) education programs in relation to national and European soil (health) policies.

The desk research followed the conceptual framework outlined in the section 3.1, however it was guided by only the GRQ1 (What is the state of soil (health) awareness education?).

Focus groups and interviews: Each partner country held 1 focus group and 10 interviews with an objective to gain deepen the insights and to corroborate, or question the findings of the desk research. The focus groups and interviews followed the same conceptual framework as the desk-research (see section 3.1) to explore the GRQ1 (What is the state of soil (health) awareness education?) and GRQ2: (What are the wishes for future soil (health) awareness education?).

The focus groups targeted the formal educational levels (primary, secondary, tertiary levels) and consisted of school teachers and university lecturers. Interviews attempted to cover formal and non-formal education and included students (tertiary level), teachers, lecturers, VET organization representatives, policy officers and NGOs and civil society representatives to cover all educational levels. The focus groups and interviews were facilitated by a semi-structured conversation and were recorded followed by a transcription. All the process were executed in accordance with the ethics and data protection guidelines specific to each country and the European Union. The detailed methodology adopted for focus groups and interviews as well as the ethical considerations are presented in Tassone et al. (2023). The table 1 presents an overview of the composition of focus groups, and interview participants in different countries.

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Table 1: Overview of the focus group and interviews conducted in partner countries.

Country	Focus group participant category (number)	Interview participant category (number)
Austria	School teacher (4), University lecturer (1), Other (1)	Primary school teacher (1), Secondary school teacher (4), Policy officer (1), Tertiary level student (1) Tertiary level lecturer (1), VET representative (1), NGO (1), Civil society representative (1)
Germany	School teacher (2), Other (1)	Primary school teachers (1), Secondary school teachers (1), Tertiary level lecturers (2), Other (4)
Greece	University lecturers (4)	Primary school teachers (2), Secondary school teachers (2), Tertiary level lecturers (2), VET representatives (1)
Hungary	School teachers (3), VET teachers (1), Other (1)	Primary school teachers (2), Secondary school teachers (1), Tertiary level lecturers (2), Students (3), Policy officers (1), NGOs (1), Other (1)
Ireland	University lecturers (1), Other (3)	Secondary school teachers (2), Tertiary level lecturers (3), VET representatives (2), Civil society representatives (1), NGOs (1), Other (1)
Italy	School teachers (4), Other (1)	Primary school teachers (1), Tertiary level lecturers (1), VET representatives (3), Students (1), Civil society representatives (1), Other (3)
Lithuania	School teachers (4), University lecturers (1)	Secondary school teachers (1), Tertiary level lecturers (6), Students (2), Policy officers (1),

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		NGOs (1), Other (1)
Netherlands	School teachers (2), University lecturers (2), VET teacher (2)	Secondary school teachers (1), Students (2), Tertiary level lecturers (2), VET representatives (1), Civil society representatives (4)
Poland	School teachers (1), University lecturers (4), Other (1)	Primary school teachers (1), Secondary school teachers (1), Tertiary level lecturers (4), VET representatives (2), Students (2), Policy officers (1), Other (1)
Serbia	School teachers (4), VET teachers (1)	Primary school teachers (1), Secondary school teachers (2), Tertiary level lecturers (4), Policy officers (2), NGOs (1)
Slovakia	School teachers (2), University lecturers (1), Other (2)	Primary school teachers (1), Secondary school teachers (4), Tertiary level lecturers (3), VET representatives (1), NGOs (1)
Sweden	School teachers (4), University lecturers (1)	Primary school teachers (1), Secondary school teachers (1), Tertiary level lecturers (3), VET representatives (1), Students (1), Policy officers (1), Civil society representatives (1), Other (1)
Spain	School teachers (5), VET teachers (2), University lecturers (6)	Primary school teachers (1), Secondary school teachers (2), Tertiary level lecturers (2), VET representatives (1), Students (2), Policy officers (1), Civil society representatives (1), NGOs (1)
Turkey	School teachers (6), University lecturers (2),	Primary school teachers (2), Secondary school teacher (2),

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	VET teachers (1)	Tertiary level lecturers (2), VET representatives (3), Civil society representatives (2), NGOs (1)
United Kingdom	School teachers (1), University lecturers (1), Other (3)	Tertiary level lecturers (5), Civil society representatives (1), Other (4)

***Questionnaire*:** Based on insights gathered from desk-research, focus group discussions, and interviews, a comprehensive overview of the 'state of' and 'wishes for' soil (health) education design for each country was developed. This overview, which did not differentiate between educational levels, was documented through a questionnaire (one questionnaire response per country, thus a total of 15 responses). In this questionnaire, LOESS partners ranked the dominance of different descriptors exploring the dimensions concerning the GRQ1 and GRQ2. The ranked data were analysed using weighted mean scores to determine the dominance of descriptors for each dimension, for the state and wishes. The detailed statistical procedure followed is presented in the Appendix A. The questionnaire was administered by the Microsoft Forms.

Verification and reflection by Communities of Practices (CoPs): The CoPs established in each of the 15 European partner countries, were engaged throughout the first study. Each country exchanged information on the approach, progress and outcomes related to the first study with their respective CoP which provided feedback on the research strategies suitable for country-specific contexts. The CoP members also provided their inputs by directing specific resources (e.g. publications, policy documents, grey literature, etc.) as well by providing suggestions about the organization of focus groups and interviews.

Once the results were drawn, each country held a 'reflective workshop', where CoP members reflected and discussed upon the findings based on the desk-research, focus groups, interviews, and questionnaire emerging in their own country, and how these country results compared with the overarching cross-countries findings. Objective of these reflective workshops was to identify what findings CoP members endorse and what are the points of contentions.

The findings of the first study are presented in section 4.1 in terms of overarching cross-country findings, and are presented in Appendix A in terms of findings for each of the 15 European countries involved in this study and distinguished per educational level.

For what concerns the **second study,** a survey was designed by the LOESS partners at UIBK, in consultation with all other LOESS partners. Here, a brief description of the survey data collection and analysis approach is provided. Further details are presented in Ashikbayeva et al. (2024).

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***Survey*:** The second study employed an online survey that targeted educators, including in-service teachers at primary and secondary schools, university educators, vocational school instructors, and educators from the non-formal sector, such as those working in Centres for Education for Sustainability, museums, science shops, education cooperatives, associations, NGOs, and experts in Experimental Science Education. The survey was created and administered using the online survey tool Qualtrics, in compliance with the General Data Protection Regulation. The questionnaire was created in English and then translated into 13 languages (based on the partners of the LOESS consortium). The survey was not incentivized and fully voluntary. It was disseminated through project partners among their networks of educators and the data collection was not restricted to the partner countries only, but also from other European countries. Further details on the survey instrument, data collection, and complete questionnaire in English is available in Ashikbayeva et al (2024).

Data was collected during 7 May - 29 July 2024 with a total of 2,644 responses. Of the submitted 2,644 responses, 355 were discarded due to missing consent and 987 were discarded because of incompleteness. Thus, 1,302 responses were finally used in the analysis. The survey data was analysed following a descriptive approach. The mean values of responses were compared for objective items (e.g., yes/no questions, as well as questions regarding age, teaching experience, etc.). or multiple-choice and Likert scale questions, the proportion of respondents selecting each possible answer was computed. In cases where respondents could select multiple options, the share of responses may not total 100%. All data cleaning and analysis were conducted using the statistical programming language R.

Number of responses submitted did not reflect the size of the countries, and significantly depended on the responsiveness of educators and the strength of the partner network. Figure 1 presents the distribution of the 1,302 survey responses submitted from different countries and analysed. A cumulative 37% responses were submitted from Poland and Turkey. Therefore, as such, the survey sample cannot be considered a representative to all educators within participating countries or the European Union. This has been considered, when interpreting the results, as responses may be influenced by the specific educational and social environments of the countries with the most responses. Furthermore, the majority of the survey respondents were female educators with a Masters Degree and an extensive teaching experience. The findings of the second study are presented in section 4.2 in terms of overarching cross-country findings.

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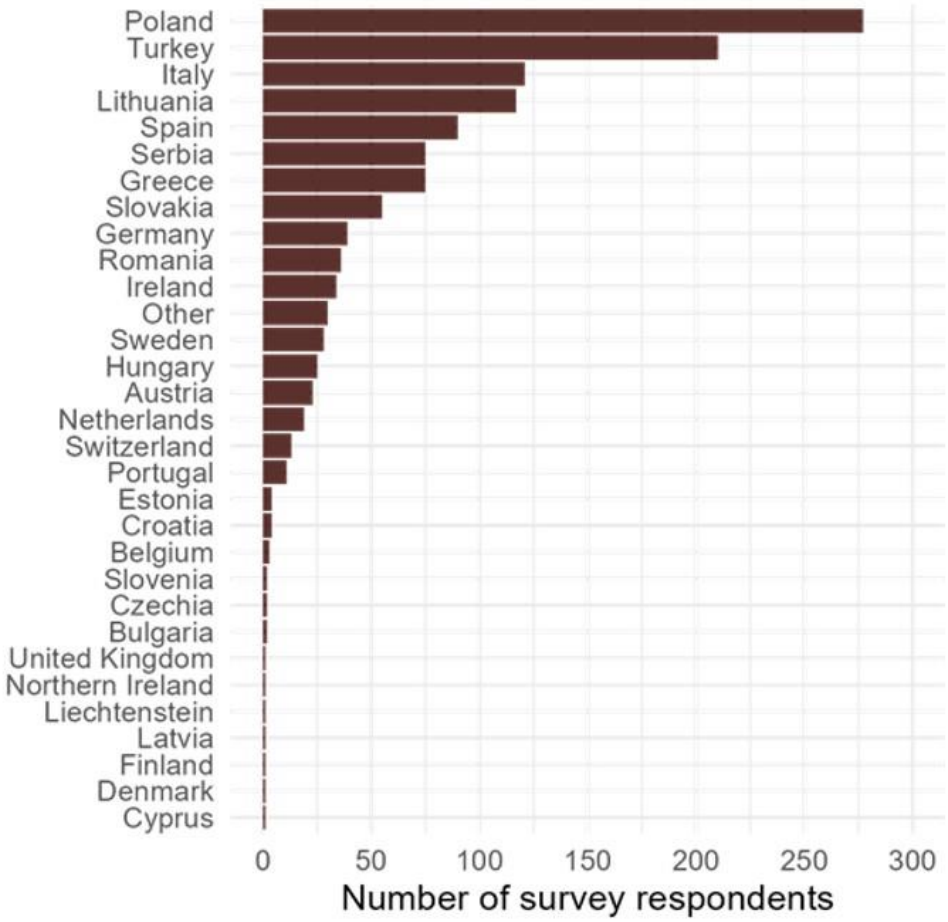

Figure 1: Distribution of survey responses by country. The bars represent the number of submitted responses that were complete in all respects and were included in the analysis.

4. Cross-country findings

4.1. Findings on soil (health) educational design

This section presents the findings of the **first study**, exploring soil (health) educational design. Soil (health) in most countries is not integrated as a specific topic or subject in the curricula, except for the tertiary level, and to a degree within VET courses in soil science and agriculture related disciplines. In some countries, this integration is a relatively new development. For example in Lithuania, soil (health)-related topics have been integrated in the recent revision, however, the textbooks are not yet updated, and hence the extent to which soil (health) is addressed in education is unclear. In some countries, e.g. Spain, soil (health) education is largely absent in the national curriculum and relies on individual teachers customizing lessons based on their own interests and materials available. In some other countries, for instance in Slovakia, soil (health) topics are being integrated more comprehensively into different educational levels.

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In general, some aspects of soil (health) are embedded in school education, mainly at the secondary level within the subjects focussing on environmental science, geography and biology. At tertiary level, depending on the disciplines, the focus becomes deeper and more specialised, however the state and the wishes for the dimensions investigated heavily depend on the discipline and specific countries. Across all education levels, there is a general focus on knowledge acquisition (*knowing*) regarding soil (health) processes and functions.

The educational design also reflected specific policies and environmental and sustainability priorities in different countries. For instance, in the Netherlands, soil (health) and water management education is intertwined and predominant across all educational levels reflecting the country's policy emphasis on land-water management nexus and significance of agriculture sector. In Greece, the EU's Common Agricultural Policy (CAP) is the target of soil (health) educational offers for the general public. In most countries, soil (health) education tends to focus on agricultural productivity and to a degree on soil (health) conservation, reflecting the economic significance of agriculture sector and soil being mainly recognized as a resource for it. Below, we present the general overview, as well as the commonalities and contrasts observed for each of the dimension across 15 partner countries.

Purpose: Across all countries and educational levels, there is a major focus of soil (health) education on the EU Mission Soil objectives to *reduce soil pollution and enhance restoration* and *to improve soil structure to enhance biodiversity* (see Figure 2). However, the specific focusses vary by the country and the educational level. Furthermore, the wishes for aligning soil (health) for EU Mission Soil objectives strongly depends on specific challenges different countries face. For instance, in Austria and Germany, soil degradation, soil pollution and soil erosion are recognised as major issues, and are reflected in their soil (health) education which aligns with most of the EU Mission Soil objectives especially in tertiary and VET education. In contrast, countries where these specific issues are not perceived as a priority, such as in Poland and Slovakia, the corresponding EU mission goals are also only weakly or not addressed in the soil (health) education. Countries with national priorities around sustainability, such as Sweden and Ireland, the soil (health) education are also strongly aligned with EU Mission Soil objectives.

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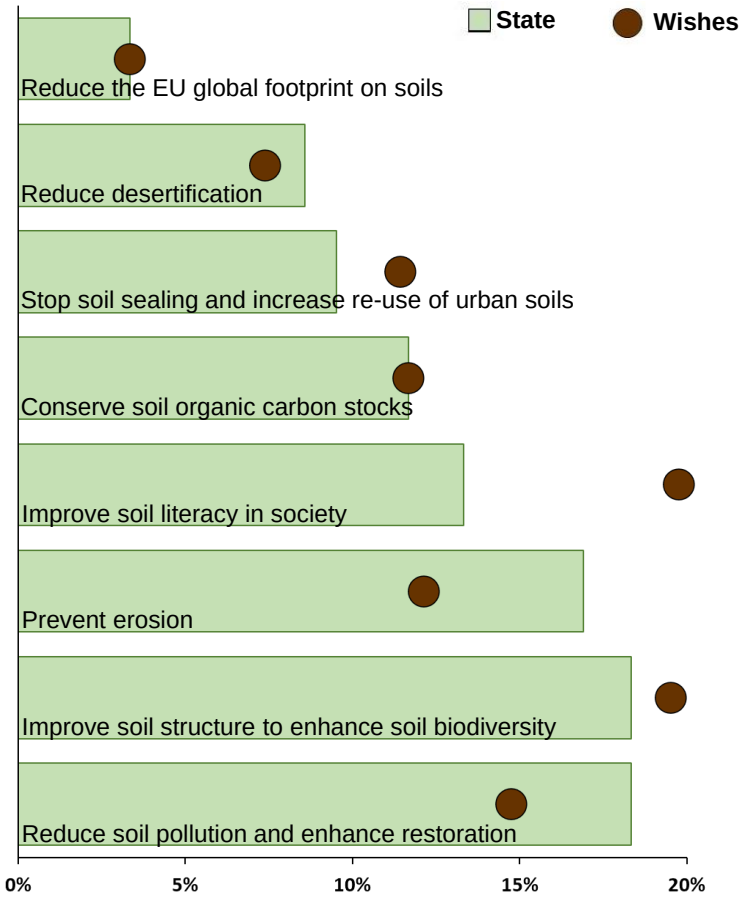

Figure 2: Graph illustrating the preference for various EU Mission Soil objectives, comparing the current State (bars) with desired Wishes (dots) in the context of soil (health) education. The horizontal axis represents the percent contribution of the mean weighted score for that descriptor. See Appendix A for detailed estimations.

Across all countries, there is a general wish for soil (health) education to better align with the EU Mission Soil objectives, however, the wish to strengthen *soil literacy in society* stands out, which also presents the widest gap from the current state. In addition, there is desire to strengthen the soil (health) education around the specific goals to *improve soil structure to enhance soil biodiversity,* and *reduce soil pollution and enhance restoration*. However, reducing the EU's soil footprint remains a lesser priority in both current and wished states.

In most countries, the links between soil (health) and SDGs are not made explicit in soil (health) education, especially in the primary and secondary educational levels. Where some connections have been made, predominantly at the tertiary and to a degree in VET education in most countries, the SDGs of *life on land, climate action* and *responsible consumption and production* stand out which may be attributed to their direct connections to soil (health) through food production and carbon sequestration (see Figure 3). These SDGs are also wished to be prioritized for soil (health) education.

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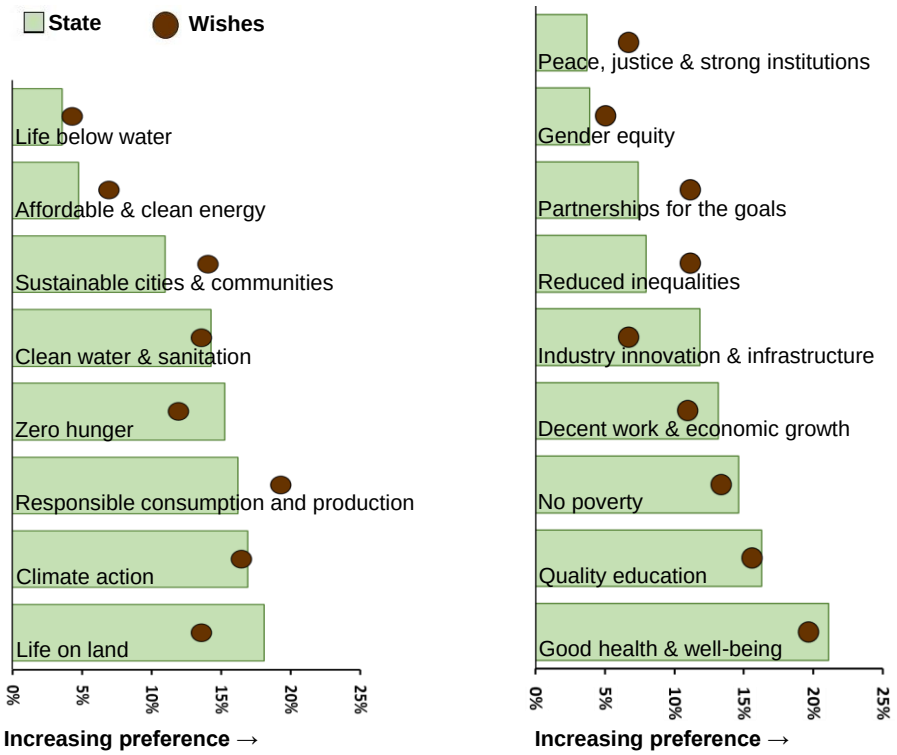

Figure 3: Graph illustrating the preference for various SDGs, comparing the current State (bars) with desired Wishes (dots) in the context of soil (health) education. The horizontal axis represents the percent contribution of the mean weighted score for that descriptor. See Appendix A for detailed estimations

However, there are differences between the specific SDGs that are prioritized across countries. For instance, in most countries including Ireland and Germany, the curriculum emphasizes connections between soil (health) and *climate action*. However, in Hungary and Poland, soil (health) education does not directly address SDGs. Most SDGs are missing from all education levels in Greece indicating a wide gap between the challenges in the country and education on addressing the SDGs *clean water and sanitation*, *climate action*, *life on land* and life *below water*.

In addition to the general wish to strengthen the SDGs of *life on land, climate action, and responsible consumption and production*, there are specific wishes across countries and educational levels. For instance, at the tertiary level across most countries, soil (health) is linked with the global challenges that include climate change and sustainable land use. In the UK, the wish is to embed all SDGs, while in the Netherlands, the wish is to strengthen broader societal SDGs that include *good health and well-being*, and *sustainable cities and communities* more deeply into soil (health) education, particularly at the primary and tertiary levels. In Hungary on the other hand, questions on how to identify specific SDG for priority emerged considering that all SDGs are important and implicitly embedded within the education system even though not exclusively in relation to the soil (health).

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In terms of human development, current soil (health) education has an emphasis on the purpose of gaining knowledge (*knowing*), while attention is also given to developing practical skills (*doing*). For example, in Italy, soil (health) education strongly prioritise theoretical knowledge over than hands-on, real-world applications, especially at secondary and tertiary levels. In VET courses however, *doing* and *knowing* become a priority in most countries so as to prepare students for professional applications. The purpose of *being* is largely missing or weakly embedded across most of the educational levels in most countries (See Figure 4). Among exceptions is the Netherlands, where the purpose of *being* is strongly embedded in soil (health) education, particularly at the primary and secondary levels when education is especially facilitated by environmental education organisations and students learn to interact with soil and reflect upon its appearance, texture, and scent. Other examples include VET courses in Turkey where connection of Turkish society and cultural heritage with soil is explored using artistic approaches such as poetry, folk songs, literature, and history.

The general wish is to shift towards a more balanced purpose of education where learning to act sustainably (*doing*), nurturing values (*being*), and knowledge acquisition (*knowing*) all are having a place in education.

Figure 4: Graph illustrating the relative importance of various descriptors used to describe the State and Wishes of the Purpose in terms of human development across 15 LOESS-partner countries. The size of each descriptor (colour) represents the percent contribution of the mean weighted score for that descriptor. See Appendix A for detailed estimations.

Collaboration: Across all countries, collaborations in soil (health) education are generally *narrow-broad* or *broad* (see Figure 5), and usually involve partnerships between schools, universities, and external organizations, such as NGOs, government agencies, and environmental education organizations. The extent of collaborations and the stakeholders involved vary according to the educational levels, disciplines and countries. For instance, at primary and secondary levels, common collaborators include students, teachers, and some external organisations (e.g. educational NGOs, municipalities and local universities). Tertiary education sees broader collaborations, often involving universities and industry partners (e.g., agriculture, soil science organizations). VET levels usually have external partnerships that allow more practical, discipline-specific learning (e.g., agricultural farms, businesses). In most countries, the general public's awareness of soil (health) is low. Comparing across countries, Germany, Hungary and the Netherlands demonstrate interdisciplinary approaches to soil (health) education, and wish for a stronger connection to societal issues and integrate international partners and industries. In some countries, external organisations play a crucial role in soil (health) education. For instance, in the UK, British Society of Soil Science is the main

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provider of soil (health) educational materials, integrated within broader topics such as biodiversity and food production for primary school students. There is a general wish to shift towards more complex and transdisciplinary forms of collaboration in education, involving teachers and students from multiple disciplines, as well as multiple actors in society such as industry, NGOs, policymakers. Countries, for instance Serbia and Lithuania emphasize the need for collaborative public education, particularly through community gardens and media campaigns. Some countries including Poland and Turkey, experience a greater gap where soil (health) education is predominantly theoretical, with limited inter- and transdisciplinary connections. In Spain, collaboration between schools and universities were identified as important to introduce scientific rigour to school teaching.

Figure 5: Graph illustrating the relative importance of various descriptors used to describe the State and Wishes of Collaboration across 15 LOESS-partner countries. The size of each descriptor (colour) represents the percent contribution of the mean weighted score for that descriptor. See Appendix A for detailed estimations.

Space: The use of *indoor* teaching spaces is prevalent across all countries at most of the educational levels, yet there is a widespread recognition of the need to expand *outdoor* learning opportunities for practical, hands-on experiences and there is a full consensus to shift from predominant *indoor* forms of education (e.g. in a classroom) to *outdoor* ones (e.g. in a garden, in a forest, etc.). See Figure 6. A few countries, such as Greece stands out for effectively utilizing school gardens at primary and secondary levels to facilitate real-world experience to the students. In contrast, most of the countries have a notable lack of outdoor educational components in soil (health) education. The wish to strengthen the outdoor learning for soil (health) education faces financial constraints and logistic constrains, most notably, the lack of accessible *outdoor* spaces, and resource for instance as identified in Sweden, Turkey, and Ireland. This limitation is higher in the urban areas where access to nature and other relevant landscapes (e.g. agricultural farms) are further limited and bringing students to such places poses administrative and financial concerns (e.g. safety, logistics, parental consent), especially for primary and secondary levels.

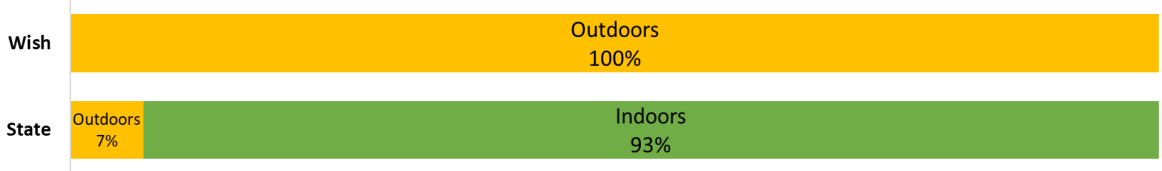

Figure 6: Graph illustrating the relative importance of various descriptors used to describe the State and Wishes of Space across 15 LOESS-partner countries. The size of each descriptor (colour) represents the percent contribution of the mean weighted score for that descriptor. See Appendix A for detailed estimations

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Activities: Soil (health) education is predominantly facilitated through a combination of *knowing-* (theoretical learning) and partly *doing-based* (practical application) activities, and to a far lesser extent *being-based* (experiential connection) activities. See Figure 7. Across all countries, there is a strong emphasis on knowledge acquisition through classroom instruction, complemented by practical activities such as fieldwork, experiments, and projects. The emphasis on different types of activities varies by country and education level. At primary and secondary levels, *knowledge-based* activities generally dominate (lectures, reading), with some components of *doing-based* activities (e.g., soil experiments). Germany and Ireland offer specific examples where *doing-based* activities are more prevalent in tertiary and, particularly in VET programs that prioritise professional skill development. Italy leverages the well- established collaborations with external experts and industries for *doing-based* activities for soil (health) education.

There is a general wish to facilitate soil (health) education predominantly through *doing-based* activities alongside *knowing-based* activities. Certain countries, such as Ireland is already increasingly incorporating *doing-based* activities in secondary education, although the primary focus remains on *knowing. Being-based* activities (reflection, value cultivation) are rare across almost all educational levels in all countries and remain for some countries a low priority in the wishes as well. Exceptions include for example Hungary, UK, and Serbia, who wish to strengthen *being-based* activities to help students reflect on the ethical and environmental aspects of soil (health) and cultivate environmental responsibility. It is however considered that *doing-based* experiential activities can help facilitating both new ways of being and new ways of knowing.

Figure 7: Graph illustrating the relative importance of various *descriptors* used to describe the State and Wishes of Activities across 15 LOESS-partner countries. The size of each descriptor (colour) represents the percent contribution of the mean weighted score for that descriptor. See Appendix A for detailed estimations.

Process: Soil (health) education dominantly employs *instructive* processes with some components of *emancipatory* approaches. See Figure 8. The typical process includes teacher-led instruction, especially in primary and secondary education, where curricula are often more structured and focused on meeting specific educational goals directed by the curricula. However, in some countries, for example in Austria, application of digital tools are employed for interactive exercises alongside presenting factual information to primary school students. VET courses are generally more *emancipatory*. For instance, in Germany, project-based and hands-on learning encourage students to engage actively with real world soil-related challenges. The Netherlands also incorporates project-based learning, particularly in secondary and tertiary education, where students are encouraged to take a

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more active role in their learning. Ireland is gradually moving towards more participatory processes, particularly in secondary education, though traditional methods still dominate. There is a strong wish across most of the countries and educational levels to shift to more *emancipatory* forms of learning with a major goal to encourage real-world problem-solving abilities.

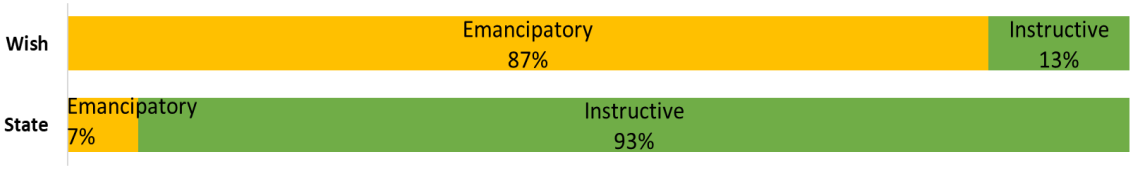

Figure 8: Graph illustrating the relative importance of various *descriptors* used to describe the State and Wishes of Process across 15 LOESS-partner countries. The size of each descriptor (colour) represents the percent contribution of the mean weighted score for that descriptor. See Appendix A for detailed estimations.

Paradigm: Currently, the *mechanistic* paradigm, which approaches soil (health) by placing an emphasis on individual components and processes (e.g. soil types, compositions and specific processes and functions) dominate the soil (health) education. See Figure 9. There is a prioritisation of specific functions of soil (health) which are seen as directly relevant for its certain biological and economic aspects of soil (health), without more broadly recognizing interdependencies and relationships across humans, non-humans, and the more than human world. Nevertheless, there is a strong wish to adopt an *ecological* paradigm, i.e. a systemic view that acknowledges interconnections between soil (health), the ecosystem and people. Achieving this is challenged by already established curricula. In this context, VET courses hold a unique position in the educational landscape as they are primarily designed to prepare future professionals. In most countries, VET courses that include soil (health) topics tend to focus primarily on agricultural productivity, without acknowledging systems-level understanding of soil (health). However, the focus of these courses on economic sectors presents an opportunity: by explicitly highlighting how soil (health) supports economic activity and the importance of its conservation.

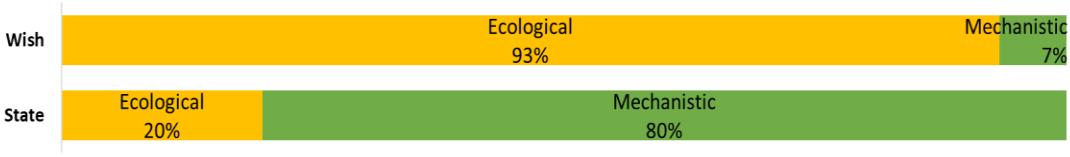

Figure 9: Graph illustrating the relative importance of various *descriptors* used to describe the State and Wishes of Paradigm across 15 LOESS-partner countries. The size of each descriptor (colour) represents the percent contribution of the mean weighted score for that descriptor. See Appendix A for detailed estimations

Case studies: During desk-research, focus groups and interviews, 5-6 case studies which provided examples of innovative educational approaches were identified in each country

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for each of the educational level. 40 of these case studies are available at the LOESS website (LOESS Project. , n.d.).

4.2. Findings on educator's needs.

This section presents the findings of the **second study**, exploring educators needs. It presents the survey findings within the context of the soil (health) education teaching, the gaps and the needs identified across Europe. All details about the findings of this second study can be found in Ashikbayeva et al (2024). The key findings can be summarised into the following points:

- Soil (health) is recognized as important by both male and female educators, yet many feel inadequately prepared to teach it.
- Teachers often rely on the internet for teaching resources due to insufficient or unhelpful materials from official sources.
- Educators desire better, easily adaptable teaching materials and more opportunities for hands-on learning.
- Awareness of the EU Mission Soil is low among educators, who are crucial for its success.

Analysis of the survey data also indicated that majority of soil (health) related teaching occurs in the secondary educational level, which coincides with the insights gained from the first study in majority of partner countries, and that it is mostly embedded within the subjects nature and environment, biology, geography and agriculture.

A key finding that emerged from the survey is that while 79% of the educators considered soil (heath) teaching very important, only 38% felt adequately trained to teach soil (health) related content. Only 30% of those teaching soil (health) topics attended any professional development sessions or workshops. This also supports the insights gained from first study that teachers need specialised professional training that enables them to deepen their understanding and teaching skills on soil (health) related topics. This was further seconded by the survey finding that teachers stay updated with the new developments in the field, e.g. regarding EU Mission Soil by educating themselves through internet and social media, and their expressed need to assess more information and training.

The survey results also supported the findings of the first study that purpose of soil (health) education prioritises upon soil pollution and soil degradation, and conservation, as well as the knowledge of soil types (see Figure 10).

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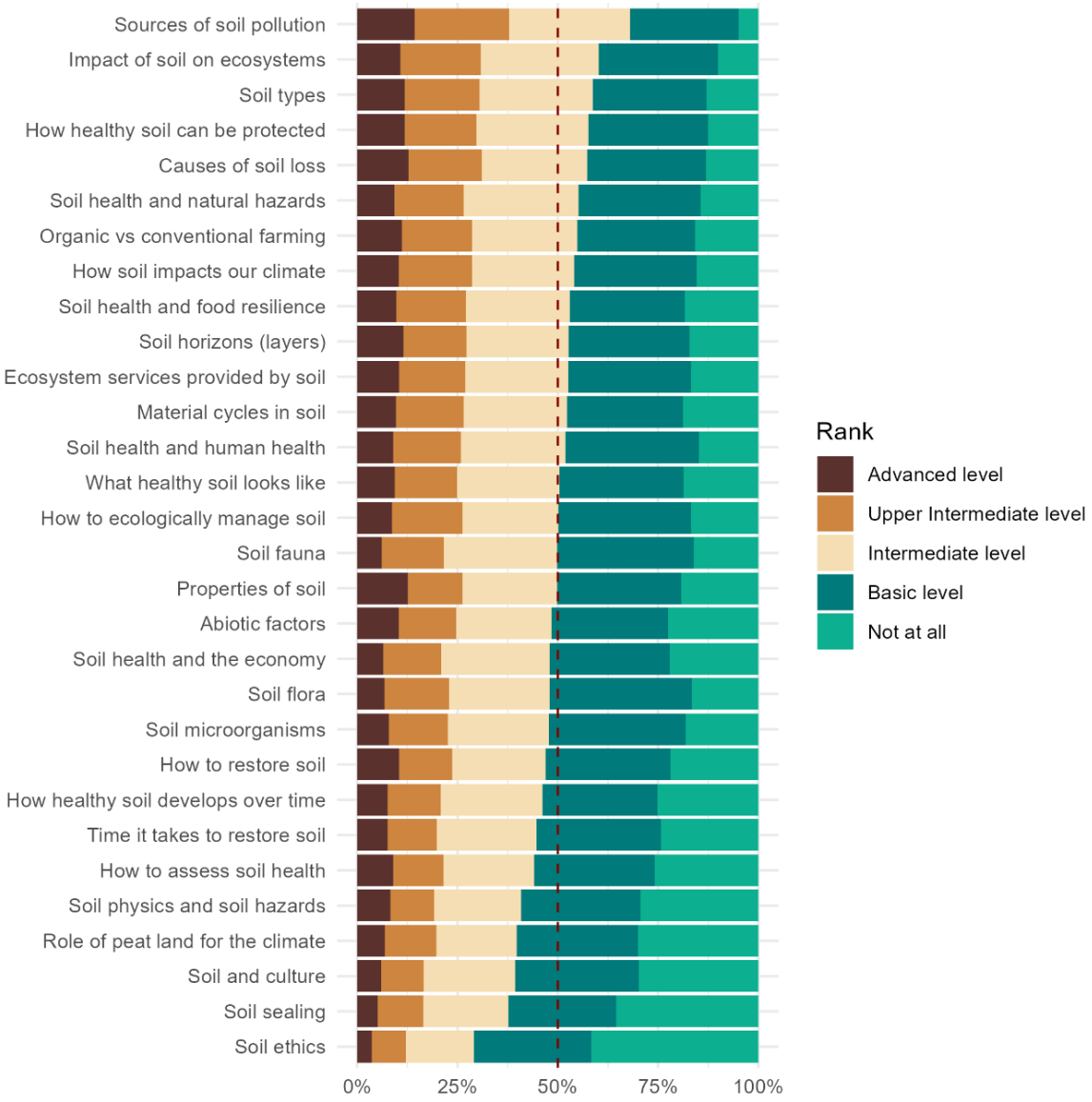

Figure 10: Figure presenting an overview of respondents' self-assessment of the level of comprehension at which they teach the listed topics'

Based on the survey of 30 soil-related topics, several key areas stood out where teachers wanted more teaching resources (see Figure 11 for details). About 40-50% of respondents requested more materials on: how soil impacts our climate; soil (health) and human health; how to restore soil; how to assess soil (health) and how healthy soil can be protected. The interest in more resources was more from the secondary school respondents compared to the primary, arguably due to the prevalence of soil (health) topics being taught at the secondary level.

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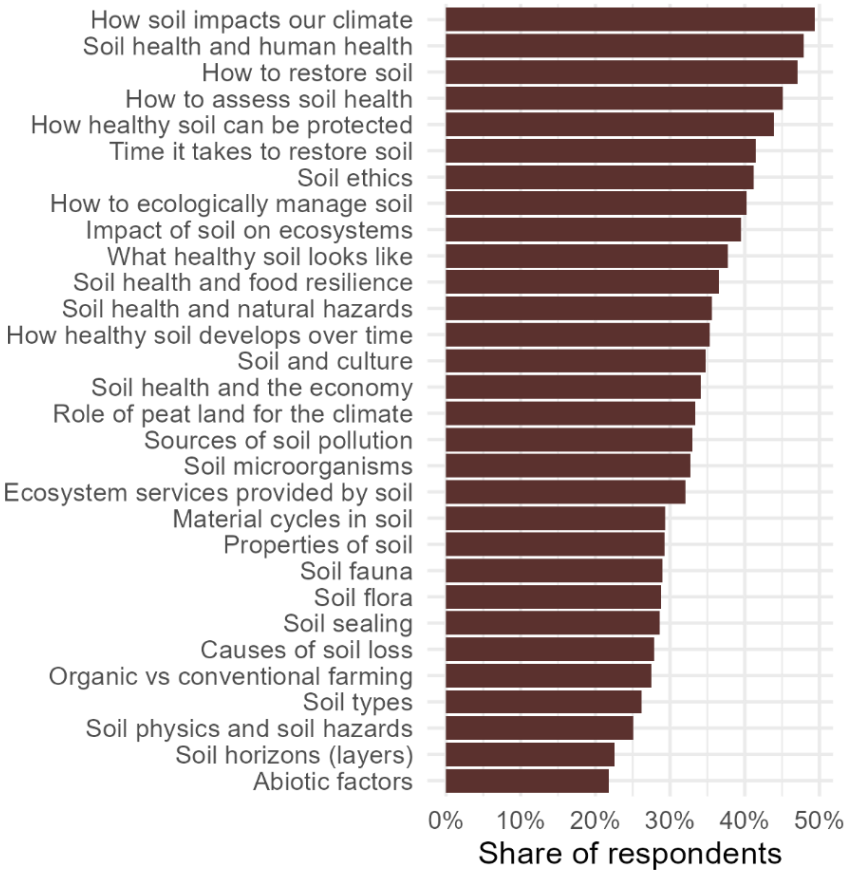

Figure 11. Figure presenting the different soil (health) topics according to the share of teachers who expressed a wish to assess more resources.

The survey findings suggest several key actions. Firstly, there is a need to boost awareness of the EU Mission Soil among educators, as they play a critical role in its success. Secondly, understanding which topics are important to teachers and identifying gaps in current teaching materials can guide the development of resources that better support classroom instruction. Finally, by catering to educators' preferences for specific types of teaching materials, tailored and effective resources can be created to enhance teaching and learning outcomes.

Educators primarily use hands-on activities (51%), field trips (45%), project-based learning (42%), and teacher-centred methods (41%) to teach soil (health) related topics, with problem-based learning used by 37%. More details are presented in the Figure 12. Those survey findings from the second study, partly align with the findings from the first study (desk-research, focus groups, interviews, and questionnaire) indicating current use of hands-on activities, and of teacher-centred methods through which teacher knowledge is transferred. The survey findings from the second study however contrasted the insights gained from the first study that indicated the dominance of *indoor* education with weaker components of *emancipatory* approaches. From the survey, only 25% of teachers were found to use self-study online resources, 16% employed creative methods, and just 13%

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attended soil exhibitions. Female teachers preferred cooperative learning and creative approaches, while male teachers leaned more toward teacher-centred teaching. The low number of male teachers respondents, compared to the female ones, might explain why instructive teacher-centred method of knowledge transfer appear as less prominent in the survey findings from the second study, compared to the findings from the first study. About 50% of teachers engaged in regional or national environmental protection efforts and kept themselves informed about soil (health) research.

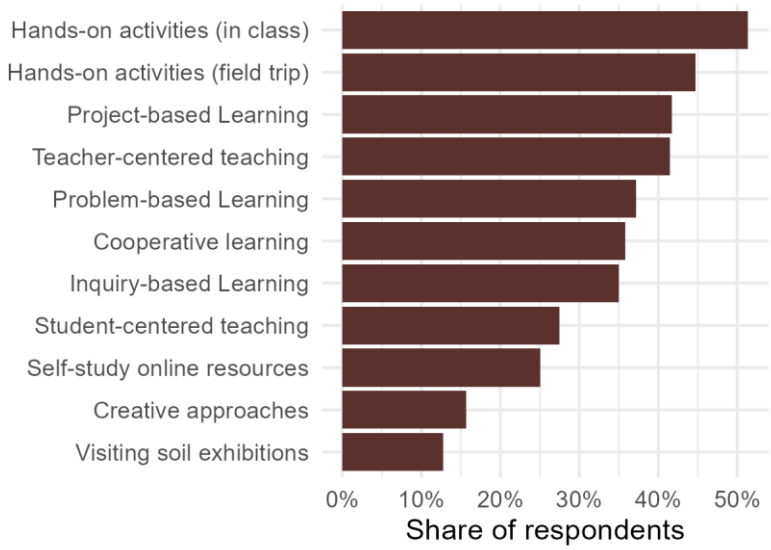

Figure 12. Figure showing the share of educators according to their teaching approaches.

Most of the teachers use resources for soil (health) related teaching from the internet (>70%), self-developed materials (~65%), or schoolbooks (~60%). In terms of collaboration, only 20% of teachers use resources developed by their colleagues. Teachers also identified the following resources that would most support their teaching: tools for experiments and field trips, opportunities to collaborate with soil experts, access to learning outside the classroom programs, and different methodological approaches. These survey findings align with the wishes for more *outdoor* and collaborative education as identified in the first study through desk-research, focus groups, interviews and questionnaire. However, teachers are less interested in obtaining new resources on creative approaches to soil (health) education and citizen science.

The survey also provided insights into the attitude and behaviours of the educators related to soil (health). Nearly half of the educators engage in regional or national environmental protection initiatives and stay updated with new soil (health) related research, and nearly 25% of the respondents participate in soil (health)-related research projects. In addition, nearly 50% of the respondents frequently purchase organic food, and around 50% believe that their knowledge about soil (health) strongly influences their purchasing decisions, suggesting their concern for soil (health) extends beyond the classroom. The survey also indicated economic safety is the top priority for the educators (>50% responders ranked economic crisis as their top concern), followed by climate change, another pandemic, and

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biodiversity loss which indicate the need for creating an economic safety for the educators.

5. Conclusions and recommendations.

One key conclusion emerging from this research, based on the first study and the second study, is the lack of integration of soil (health) topics from the formal and non-formal curricula in most countries, especially at the primary levels, and in the educational offers available to the general public. Some countries such as Spain, Sweden, and the Netherlands explicitly mention the importance of systematic inclusion of soil (health) related topics within their curricula. In addition, the importance of soil (health) for various SDGs need to be made more explicit and the soil (health) related topics need to be aligned with the EU Mission Soil objectives. Across educational levels, there is a general lack of inter- and transdisciplinary approaches, and soil (health) is often taught in isolation from broader socio-ecological contexts.

Overall, there is the wish to facilitate forms of education that enable learners to develop holistically as whole persons, which implies balancing the purpose of learning to do, to be and to know. Comparing the state and the wishes, there is a disparity in the dimensions of learning space, process, activities and paradigms. Although some countries show examples that are closer to the envisioned *outdoor, emancipatory, doing-based* education grounded on an *ecological* paradigm, most countries face significant logistical and financial constraints in implementing these aspects. To close these gaps, several macro and micro level actions are needed.

Amongst the microlevel needs, the importance of improving educator's training stands out. Both research and survey reveal that educators, especially those in the formal education need, and express the wish for training that provides them a better understanding about soil (health) as a topic, as well as in terms of pedagogic approaches that enables them to design and implement more *outdoor, emancipatory, doing-based experiential* approaches. Educators also need teaching materials on soil (health) and on the interconnections between soil-ecosystems-humans to assist them facilitating soil (health) education based on an *ecological* paradigm.

A key challenge identified is the lack of time and resources educators and students face, and the overall rigidity of the educational system. In fact, current rigidity of well-established curricula in terms of pre-set educational purposes, learning outcomes and topics that need to be formally covered in the curricula leaves a limited space and reduces teachers motivation for embedding new topics, for exploring new educational avenues and for implementing the wished changes in the educational design. For general public, there is need to create more offers and make them engaging.

Addressing these challenges calls for some major macrolevel transformations that goes beyond the effort of including the soil (health) topics within the existing curricula. There is a

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need to revisit and transform the educational purposes and assessment criteria for students and educators performance. In most countries, including the UK, Ireland, Lithuania, and Turkey, students face significant pressure to excel in standardized examinations (e.g. GCSE or university entrance examinations). This narrow focus on academic achievement often marginalizes topics and activities that do not directly contribute to examination success, which are primarily knowledge-based. So, for example engaging into activities enhancing sensibilities and care towards health of soil might be wished for, but it is a challenge to implement them given they are in some contexts less valued and not contemplated in the standardized curricula. Research suggested that experiential activities can act as levers, when educational structures allows, to foster not only relevant knowledge, but also for cultivating hands-on skills and personal connection and sensibilities towards soil supporting holistic development of learners as whole persons.

In addition, there is also a need for financial and policy support to educators and educational institutes. To implement, *outdoor, emancipatory and doing-based experiential education,* which is considered crucial for soil (health) education, educators and students need resources such as outdoor spaces, access to laboratories, etc. and financial support to cover the operational costs and fund the projects that align with these approaches. There is also a need to encourage, facilitate and support transdisciplinary collaborations, bringing together different disciplines and sectors where educators and students can learn and share resources with other academic and non-academic organisations, NGOs, businesses, farms, external projects, policymakers, etc. Therefore, embedding these aspects within the educational policies become important.

Despite the challenges, several examples were identified that present inspiration and demonstrate models and practices in the direction of the wished for soil (health) educational content and design. These include active role of educational NGOs in providing nature focussed education in the Netherlands's schools, and prominent use of school gardens in Greece with a focus on *outdoor*, hand-on learning. Spain, the United Kingdom, and Serbia emphasize the potential for engaging the general public through participatory and citizen science projects, and there are examples where students already participate in such projects (e.g. EU-Citizen.Science., n.d.). A set of promising educational offerings across Europe, that demonstrate implementation of innovative soil (health) education approaches in line with the wished forms of soil (health) education described in this report, are presented online in the LOESS website as case studies (LOESS Project. , n.d.).

A comparison across countries indicate a varying degrees of gaps between the state and the wishes for different dimensions of the educational design. For instance, Germany and the Netherlands indicate satisfaction with their current educational design, which integrates *doing-based* and hands-on, *collaborative* and *outdoor* learning in soil (health) education. In contrast, countries including for example Ireland, Lithuania, and Turkey show wider gaps and wish to increase *outdoor,* experiential, and interdisciplinary approaches to soil (health) education. Interestingly, in the later cases, there is a predominance of more conventional, *knowing*-focused curricula, and lack resources for implementing hands-on learning. Overall,

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countries with narrow gaps have more collaborative, holistic and applied educational models, while those with wider gaps seek to overcome constraints and shift toward *outdoor, emancipatory, doing-based experiential* learning within an *ecological* paradigm.

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Appendices

A. Country-specific findings

This Appendix A, presents findings for each of the 15 country partners, as emerging from the first study.

A.1. Austria

Educational design in relation to soil (health) education differs across various educational levels in Austria. However, there is a certain integration of EU Mission Soil objectives in curricula, albeit with uneven inclusion of SDGs. Primary education focuses on foundational knowledge about soil functions and biodiversity, with limited integration of SDGs. Moving towards secondary and tertiary education levels, the linkages between soil (health) and broader SDGs such as climate action, gender equity, and life on land, strengthen. Throughout the educational levels, collaborations are primarily *narrow* but with a growing wish for broader engagement, especially involving external experts and interdisciplinary approaches. *Indoor* teaching spaces dominate, yet there is a strong wish to expand *outdoor* education opportunities, particularly for practical learning experiences. *Emancipatory* processes are desired to be more prominent across all educational levels, moving beyond mere knowledge acquisition to fostering deeper engagement among learners' *Mechanistic* paradigm, which emphasize biological and economic perspectives of soil, are prevalent across all levels but are more pronounced in vocational education. *Ecological* paradigm, which consider soil (health) as an integral part of ecosystem health and sustainability, are increasingly wished for, particularly in secondary and tertiary education. There is a notable lack of soil (health) educational offers available to the general public, which adds into the general lack of awareness on SDGs.

> As simple and as low-threshold as possible, please [to implement emancipatory processes in soil health education].
> *-A university lecturer (from focus group).*

Primary education

Vision: To foster an appreciation for soil (health) and its value for sustainable development.
Needs: To transition from predominantly *indoor* soil (health) education to more *outdoor* focused learning experiences by addressing the gaps in relevant educational materials and interdisciplinary collaborations.
Opportunities: Digital and multimedia tools, like multimedia soil profiles and platforms such as the Soil Compass, offer a concrete opportunity for interactive learning and exploration of real-world soil environments. They align soil education with the framework of sustainable development education, fostering collaborative teaching approaches across subjects to deepen students' holistic understanding of soil's environmental and societal importance.

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State and wishes of soil (health) education

Purpose: At primary education level in Austria children seem to be not in direct contact with soil and plants, which in turn affects their connection with these vital elements. At this level, the following Mission Soil objectives are embedded within curricula: *preventing erosion, improving soil structure to enhance soil biodiversity stopping soil sealing and increase re-use of urban soils*. In primary schools' soil (health) education does not talk about the direct connections with the SDGs, however they appear indirectly, especially addressing *zero hunger, good health and well being, life on land, responsible consumption and production* and *climate action*. Connections to other EU Mission Soil objectives and SDGs are lacking in the curriculum.

In terms of human development, the purpose of soil (health) education is focussed primarily on *Knowing* with occasional focus on *doing.* The purpose of exploring and developing personal relation with soil (health) is partly weakly embedded. A wish is to educate the leaners holistically on the topic of soil (health) to develop a systemic understanding. For instance, soil (health) education primarily focuses on soil functions. It can be booked by teachers and is delivered through a two-hour workshop for pupils from third to ninth grade. The workshop is conducted by educators in schools, and includes two parts: an introductory session that uses playful methods to convey knowledge about soil functions, and a hands-on workshop where pupils conduct their own soil research, supported by experts in the field. This approach allows students to experience soil with all their senses (Boden macht Schule, 2020). Another example is learning about certain aspects of soil (health) (e.g. soil composition, soil formation, role of flora and fauna in soil formation, biodiversity in soil, etc) using crossword puzzles (AGES, n.d.). A wish is to prioritise the purpose of *being*.

Collaboration: Soil (health) education in primary schools in Austria is predominantly *narrow* and is limited to school setting of teacher-student interaction. There are some examples (e.g. certain projects of the Museum 'inNatura', where parents, who are farmers themselves, engage in knowledge sharing. The wish is to achieve *narrow-broad* collaboration with external experts and engaging educational materials such as films. Ideally educational materials should be combined with field trips.

Space: Soil (health) education in primary schools in Austria is primarily conducted *indoors* with some components of *outdoor* education which often occur in school gardens. The wish is to offer soil (health) education predominantly *outdoors*.

Process: Soil (health) education in primary schools in Austria is primarily facilitated through an *instructive process* which relies on the textbooks. It is supplemented with some components of *emancipatory learning*, mostly during field trips. For instance, a focus group participant shared an example where a primary school incorporate regular gardening lesson that combines *emancipatory* and *instructive* processes. The wish is to transition towards educational processes which are more *emancipatory,* while still nurturing the *instructive* processes.

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Activities: In the primary education, soil (heath) education is facilitated by predominantly *Knowing-based* activities, with some minor components of *being-based* activities. *Doing-based* activities are weak. There are supportive material and digital tools that provide knowledge but also encourage learners to learn via certain activities. For example, The web based platform 'Soil Compass', features multimedia soil profiles ("Here we go out into nature"), which include short videos, pictures, and interactive information (e.g. https://www.bodeninfo.net/projekte/, 23.07.2024). teachers can book project activities to bring the natural world into the classroom, allowing students to explore and apply their knowledge through self-guided exploration in nature. The wish is to focus on *doing-based activities* for primary education.

> I think it's really important that every child has planted something that they then harvest.
> *-A primary school teacher (from interviews).*

Paradigm: A review of soil education resources for primary schools indicates a greater emphasis on *ecological paradigm* with some components of *mechanistic* paradigm. The wish is to strengthen the *ecological* paradigm.

Gaps, challenges & opportunities

There is a significant gap in the integration of Mission Soil objectives and the SDGs into soil (health) education. While there is a wish to transition from *indoor* to *outdoor* education for soil (health) education at primary level, there is a shortage of relevant educational materials and resources. Interdisciplinary collaboration remains challenging, making it difficult to integrate soil (health) across subjects. Moreover, the connection between soil (health) and human development is often overlooked, leaving a gap in understanding how soil impacts the nutrient composition in food plants, economics, and overall well-being.

To address these challenges, there is need to enable teachers to integrate soil (health) within their teaching effectively and for demonstrating its connections to sustainability that students at primary level can relate to. This includes providing training to the teachers and creative teaching approaches such as including storytelling and personal narratives (e.g. talking about their home gardens). These methods can significantly enhance student engagement and understanding, fostering a deeper connection with soil (health) issues and promoting environmental stewardship from an early age.

Digital and multimedia tools, such as multimedia soil profiles and platforms like the Soil Compass, enhance soil education by enabling interactive learning and exploration of soil environments. Integrating soil (health) into curricula through the framework of education for sustainable development emphasizes holistic teaching methods. Promoting collaborative educational approaches among educators will support a comprehensive understanding of soil's environmental and societal importance across various subjects.

Secondary education

Vision: To enhance practical and relational understanding of soil (health) that is facilitated in more emancipatory manner through broad collaborations.

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Needs: To create engaging, and age-appropriate resources that facilitate outdoor, hands-on learning experiences. These materials should integrate both mechanistic and ecological paradigms and effectively connect soil (health) with broader human development and sustainability goals.
Opportunities: The existing initiatives where students can work on farms present an inspirational example of collaboration that may be formalized in direction of achieving envisioned changes.

State and wishes of soil (health) education

Purpose: The secondary education in Austria include soil (health) related topics which embed certain Mission Soil objectives such as *stopping soil sealing and increasing re-use of urban soils, reducing soil pollution and enhancing restoration* and *improving soil structure to enhance soil biodiversity*. However, goals like *reducing the EU global footprint on soils* and *improving soil literacy in society* are weakly embedded, if taught at all. The soil (health) related topics also address the connections with SDGs *zero hunger, clean water and sanitation, sustainable cities and communities, climate action* and *life on land*. There is wish to strengthen the connections of soil (health) education in relation to *reducing desertification, conserving soil organic carbon stocks* and *stopping sealing* and *increase re-use of urban soils.* These aspects are crucial for understanding soil (health) interrelations, emphasizing its historical significance and its role as essential habitat for human prosperity and sustainability. In addition, there is a wish to strengthen the connections between soil (health) and *clean water and sanitation, zero hunger, good health, life on land, climate action.*

In terms of human development, soil (health) education at secondary level is predominantly focussed on *knowing* with some weaker components of *being and doing*. Some educational materials available for the secondary levels suggest performing experiments (*doing*) related to soil minerals (Umweltbildung, 2024). The wish is to shift towards an approach to soil (health) education that incorporates all the three aspects *knowing, being* and *doing*.

Collaboration: Soil (health) education in secondary schools in Austria is predominantly *narrow*. It is occasionally *narrow-broad* with limited involvement of external partners. For instance, a representative of the civil society shared an example from Tyrol. here school students are offered the opportunity to work on a farm for a day or two. The wish is to make collaborations *narrow-broad and broad*.

Space: Soil (health) education in secondary schools predominantly occurs *indoors* complemented by a few *outdoor* activities (e.g. field trips). The wish is to integrate *outdoor* teaching alongside *indoor* methods to enrich soil (health) education comprehensively.

> Sometimes there is not much contact to out of school learning.
> *-A civil society representant (from interviews).*

Process: At the secondary level, teachers employ *instructive, emancipatory*, or a combination of both processes for soil (health) education depending on their interest and

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preferred approach. Interview analysis indicate a greater emphasis on *instructive* processes. The wish is to transition soil (health) education towards predominantly using *emancipatory* and transdisciplinary processes.

Activities: At secondary education, *knowing-based* activities are dominating soil (health) education and are primarily cantered on reading the textbooks. The wish is to adopt an approach where all *doing-, and being-based* activities are predominantly incorporated.

Paradigm: Soil (health) education for secondary education follows mainly the *mechanistic* paradigm. It is however, intertwined with promoting engagement in discussions about the value of interconnected natural resources like water, air, and soil, and responsible human behaviour, and thus in those cases the soil (health) education partly follows an *ecological paradigm*. The wish is creating a balance between both *mechanistic* and *ecological paradigms*.

> If the soil is barren and dry, nothing can grow on it, nothing can live on it.
> *-A secondary school teacher (from interviews).*

Gaps, challenges & opportunities

The relationship between soil (health) and human development is largely underexplored, leading to significant gaps in educational resources and awareness. Additionally, there is a notable deficiency in resources that connect soil (health) with the SDGs. Existing soil education resources are frequently tailored for students aged 9 to 14, lacking differentiation to cater varying age groups. The wished shift towards more *outdoor* and *emancipatory* educational approaches is challenged by the lack of relevant resources available to teachers. Furthermore, it was recognised that time constraints and the challenge of finding affordable experts in specific fields further complicate the desire of achieving *broad* collaboration in soil (health) education.

To address these issues, there is a need for creating school-friendly resources that facilitate experiential learning, helping students transition from predominantly knowledge-acquisition to more experiential understanding on soil (health) and related topics. Alongside, a stronger balance between *mechanistic* and *ecological* paradigms into curriculum-relevant topics is needed. Overcoming these challenges requires the development of versatile, engaging, and age-appropriate educational materials that bridge the gap between soil science and human development, while also ensuring accessibility and practical applicability for teachers and students.

Tertiary education

Vision: To transition towards an integrated approach that incorporates knowing, doing, and being-based approaches in soil (health) education, and to emphasize a predominant ecological paradigm.

Needs: To facilitate the adoption of outdoor learning approaches by developing pertinent resources and providing financial assistance.

Opportunities: Activities like interdisciplinary study weeks/summer or winter schools, where multiple disciplines converge on trans-disciplinary topics, provide a valuable opportunity to present soil (health) as a central and integrative element.

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State and wishes of soil (health) education

Purpose: In Austria, university curricula vary significantly across institutions and disciplines. For instance, the curricula the University of Natural Resources and Life Science (BOKU) offers (https://boku.ac.at/en/) focus extensively on soil (health)-related topics. However, teacher education for secondary schools, which is offered by Universities and Pedagogical Colleges, places less emphasis on soil (health) education.

> I think it [soil (health)] is simply a topical issue. It is very much linked to the question, "what the future holds for humanity and do we have a good basis for this?
> *-A university lecturer (from interviews).*

In addition in the contrary Geography students learn about fundamental processes in geomorphology, hydrogeography, soil, and vegetation geography, with the knowledge to accurately identify state forms of soil. They develop skills in independent observation, mapping, and analysis of processes, forms, and conditions in natural environments (Bachelorstudium Geographie, UIBK, 2019). In these courses, almost all Mission Soil objectives are embedded, with an exception of *improving soil literacy in society* which is weakly present. SDGs play an important role in curricula planning and therefore are also present in the tertiary level education. SDGs *zero hunger, good health and well being, sustainable cities, climate action, life on land*, are strongly present in the curricula, however, the connections between soil (health) and SDGs are not clearly drawn. The wishes are to strengthen the focus on *desertification, reducing soil pollution, improving soil structure to enhance soil biodiversity*.

In terms of human development, the purpose of soil (health) education is predominantly the knowledge acquisition (*knowing*) with some weak components of practical experience (*doing*) and building personal relationship with soil (*being)*. The wish is to strengthen *being* and *doing*. These observations align with the insight gained from the interviews. Most tertiary level education overlooks soil (health) as a individual entity, and focusses more on its role as a foundational substrate for ecosystems rather than its own structural and health considerations.

Collaboration: Tertiary level soil (health) education at Universities has a predominantly *narrow* collaboration, usually limited to professors and students with occasional engagement of external collaborations that usually occurs during field trips. The wish is to expand towards *broad* collaboration for example with local forest management or field trips. This is different in Universities of Applied Sciences such as the BOKU mentioned above.

Space: The learning space for soil (health) education at tertiary level is primarily *indoors,* complemented with *outdoor* field trips. The wish is to strengthen *outdoor* learning with components of *indoor* education.

Process: At tertiary level, the process is mainly *instructive* and complemented by some *emancipatory* processes specifically during field trips. The wish is to strengthen *emancipatory* processes.

Activities: At the tertiary educational level in Austria, soil (health) education primarily emphasizes *knowing*-based activities, however, *doing-based* activities are also

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embedded to some degree. *Being*-based activities are rare. Wish is to integrate and nurture all three *knowing-, doing-* and *being-* based activities.

Paradigm: Both *mechanistic* and *ecological* paradigms are present in tertiary level soil (health) education in Austria, however, the *mechanistic paradigm* dominates. The wish is to create more focus on *ecological paradigm*.

Gaps, challenges & opportunities

Currently, there is a lack of availability of specialized educational resources that support the integration of *outdoor*, hands-on learning experiences (*being*) and foster a personal connection with soil (*doing*), while meeting students' professional needs. Financial constraints further restrict the opportunities for practical in-field learning. While there is a wish to approach soil (health) education from a broader *ecological* paradigm, it is also acknowledged that the choice between *mechanistic* and *ecological paradigms* often depends on disciplinary focus and course learning goals. There is need to adopt a balanced approach that incorporates elements from both paradigms. Furthermore, soil (health) education need to be embedded more prominently into the curricula, with clear emphasis on how it connects to broader sustainability goals.

Vocational educational training (VET)

Vision: To adopt a holistic approach to soil (health) education that combines the agricultural objectives with ecological understanding and ethical considerations for long term soil (health).

Needs: To expand VET courses related to soil (health) beyond agriculture's economic aspects, integrating broader attributes aligned with the EU Mission Soil and SDGs, while fostering engagement through innovative approaches and enhancing multidisciplinary collaborations.

Opportunities: The existing program Schule am Bauernhof (The school on the farm) exemplifies how VET students can receive experiential education aligned with principles of Education for Sustainable Development by working on a farm.

State and wishes of soil (health) education

Purpose: The VET courses addressing soil (health) in Austria embed the Mission Soil objectives of *reducing desertification, conserving soil organic carbon stocks* and *preventing erosion* while reducing the *EU global footprint on soil is weakly embedded*. VET courses also address certain SDGs, primarily *clean water and sanitation, decent work and economic growth, industry, innovation and infrastructure*, however other SDGs are weakly embedded or are absent. The wish is to integrate all EU Mission Soil objectives and all the SDGs in soil (health) education at VET level.

> I think there are SDGs that do not correlate directly [with soil (health)], but there is hardly an SDG that does not correlate with it [soil (health)]. I believe that this is the difficulty: it [soil] is simply everywhere and [one] cannot really be focused on it.
> *–A VET representative (from interviews).*

In terms of human development, soil (health) education in VET primarily focuses on *doing while being is weakly embedded*. For instance, 'The School on the farm' has evolved into an

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attractive alternative source of income with numerous positive side effects for the entire agricultural sector, particularly benefiting small-scale farms and supporting doing and knowing (Zukunftsraumland, n.d). The purpose of knowledge acquisition (*knowing*) and exploring personal relationships (*being*) are either weakly embedded or absent in most VET courses. The wish is to follow a purpose where all three-*knowing, doing and being* are embedded.

Collaboration: Collaborations in Soil (health) education in VET in Austria is predominantly *narrow* and is predominantly within the agriculture sector. *Narrow-broad* collaborations are moderate, and *broad* collaborations are rare. The wish is to achieve *broad* collaboration and integrate ethical aspects and social sciences into soil (health) education.

Space: A revision of the courses indicate that most soil (health) education related VET programs are designed to take place both *indoors* and *outdoors*. These courses predominantly seem to have *outdoor* practical lessons alongside *indoor* teaching in classrooms and laboratories. However, insights from interviews indicate, that courses primarily take place *indoors* with some *outdoor* components. The wish is to achieve a balanced combination of both *indoor* and *outdoor* learning experiences.

Process: In soil (health) education related VET programs, both *instructive* (primarily during classroom lectures) and *emancipatory* processes (primarily during field-trips) are present, however, the *instructive* processes dominate. The wish is to achieve a balanced combination of both *instructive* and *emancipatory* processes.

Activities: The VET education in Austria is primarily facilitated by a combination of *knowing*- and *doing-based* activities, while *being*-based activities are either weakly embedded or absent. The wish is to integrate all three- *knowing-, doing* and *being*-based activities.

Paradigm: In VET programs, soil (health) education is approached from a combination of *mechanistic* and *ecological* paradigms. Most courses focus on the significance of soil and plant cultivation, emphasizing soil fertility and health, while considering biological and economic perspectives. A detailed focus on soil management and fertilization, including the use of farm-specific fertilizers, is emphasized, considering production areas, market dynamics, sales strategies, and regional conditions (RIS, Land- und forstwirtschaftliche Berufsschulverordnung, 2024).

Gaps, challenges & opportunities

In VET courses that address soil (health), there is a predominant emphasis on the economic aspects of soil, especially in agriculture, while broader attributes related to the EU Mission Soil and SDGs receive less attention. This narrow focus also limits the comprehensive understanding necessary for sustainable soil management practices. Another challenge involves balancing professional requirements and grading system expectations, which makes incorporation of *being-based* activities les attractive. Additionally, there appears to be a lack of student interest and engagement in soil (health)-related topics in general. To address these challenges, there is a need for more innovative approaches to foster curiosity. The wish to strengthen *outdoor* components and broaden collaborations can help addressing this. In this

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direction, there is a need to encourage multi-disciplinary and multisectoral collaborations which extends beyond agricultural aspects and allows for incorporating diverse perspectives.

General public

Vision: to enhance soil (health) awareness for the general public by integrating the education on SDGs and fostering outdoor, hands-on learning experiences.
Needs: To develop soil (health) educational programs tailored for the general public, focusing on broad collaboration and the envisioned design of outdoor emancipatory approaches.
Opportunities: Existing programs such as 'Bildungsort Garten' (Educational gardens) present an opportunity to extend an inspirational model to other programs to implement more outdoor education.

State and wishes of soil (health) education

Purpose: Offers focussing on soil (health) education available to the general public embed several EU Mission Soil objectives, which include *improving soil structure to enhance soil* biodiversity and *conserving soil organic carbon stocks* as well as some SDGs which include *no poverty, zero hunger, good health and well-being, decent work and economic growth, sustainable cities and* communities and responsible *consumption and production.* Interestingly they do not explicitly address *improving soil literacy in society as a topic.* SDGs like *climate action, gender equity* and *life on land* are weakly embedded. For instance, the workshops offered by NGOs such as 'Klimabündnis and 'Südwind' attempt to connect soil (health) with SDGs with a particular focus on the ethical aspects of soil use (Aschenbrenner 2020). A Wish is to place emphasis on additional goals of *reducing desertification, stopping soil sealing and increase re-use of urban soils, reducing soil pollution and enhance restoration* and *preventing erosion,* and on SDGs *clean water and sanitation* and *climate action.*
In terms of human development, the purpose seems to be *knowing* and *doing*. The purpose of *being* is weakly embedded. For example, in 'Südwind' workshops (Südwind 2024), participants learn about the role of soil as the foundation of life and livelihoods for smallholder farmers. They explore how the harvesters used in cocoa, banana, or rice cultivation interact with and manage soil. The wish is to strengthen *knowing* and *being*.

Collaboration: The soil (health) related education for the general public involves collaborations that span across *narrow, narrow-broad and broad* scopes. The envisaged forms of collaboration is *broad*.

Space: The learning space for soil (health) education for the general public incorporates both *indoor* and *outdoor* environments depending on the specific offer. The outdoor components generally include field trips. The wish is to have predominance of *outdoor* education for the general public.

Process: A review of Soil (health) Awareness Offers available to the General Public indicates a dominance of *instructive* process in combination with *emancipatory* processes. In contrast, the interviews indicate a dominance of *emancipatory* processes and activities

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that involve field trips. The wish is to strengthen the components of *emancipatory* process.

Activities: In soil (health) awareness offers for general public, a combination of *Knowing*-based and *doing*-based activities are adopted. For instance, there are educational gardens (Koppitsch, 2023), which follow the idea of taking education out into nature, the forest, and the garden while also promoting networking among people. The wish is to further strengthen the *knowing*-based activities (e.g. learning about impact of fertiliser application to soil) with an expectation that this will lead to behaviour change.

Paradigm: No insights on the aspect of paradigms could be gained from the desk-research, focus groups or interviews, in the context of soil (health) education targeting general public.

Gaps, challenges & opportunities

There are very few numbers of educational offers available to the general public which adequately incorporate concept of soil (health). Validating the quality of these educational materials poses additional challenge, raising concerns about their effectiveness. Furthermore, there is a lack of general awareness on SDGs, which limits explicit integration of these goals into soil (health) education. Consequently, lack of knowledge about soil (health) often leads to ecologically harmful decisions, such as improper gardening practices and land management techniques. Specific changes wished for educational design, for example implementing more *outdoor* education face difficulty from the lack of dedicated suitable spaces, particularly in urban areas. To address these gaps and challenges, there is a need for a coordinated effort that brings together various stakeholders such as local politicians, architects, and gardeners in creating high-quality, engaging educational resources and implementing such offers.

Examples such as the 'Bildungsort Garten' (Educational gardens) present an opportunity to extend an inspirational model to other programs to implement more outdoor education (Koppitsch 2023).

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A.2. Germany

In Germany, soil (health) education exhibits a strong focus on the purpose of knowledge acquisition (*knowing*), which is considered foundational for taking action (*doing*), while the purpose of *being* very weakly embedded. However, the focal topics and depth of knowledge acquisition varies depending upon the educational levels. Primary education focusses on facilitation of developing basic knowledge about soil (health) whereas secondary education broadens the scope and presents soil (health) is a broader context of SDGs and challenges that soils face in Germany. Tertiary education partially achieves a more comprehensive coverage of the EU Mission Soil within the framework of the Sustainable Development Goals (SDGs). Across all educational levels, *mechanistic* paradigm dominates, especially focusing on the aspects of soil composition, function, and its role in ecosystems with little emphasis on the interrelationships of soil (health) with broader ecological and human systems. Collaborations in developing and delivering educational materials primarily occur within similar sectors. While learning spaces are predominantly *indoors*, occasional *outdoor* components are included.

> Before I can act, I have to know something.
> *-A university lecturer (from focus group).*

Across all educational levels in Germany, there's also a common wish to strengthen the presence of Mission Soil objectives and SDGs in soil (health) education, as well as there is a general interest in collaborations to fit the educational goals and contexts of different levels. For instance, in tertiary education, the wish is to emphasize a broader development of knowledge of the importance of soil (health) for achieving EU mission goals and SDGs. In VET courses, the focus is on making these connections more explicit within practical skill development, particularly related to *climate action* and specific environmental goals. For the general public, the major wish is to shift towards a more engaging learning experience that incorporates *doing-* and *being-based* activities.

Primary education

Vision: To transition towards an *ecological* paradigm that recognizes the role of soil (health) in broader ecosystem and societal functioning.
Needs: To enable teachers through specialized training, allocation of required resources (specifically outdoor spaces and financial support) and opportunities to implement the envisioned soil (health) educational design that include *emancipatory* approaches.
Opportunities: Successful models of incorporating *being-based* activities and *broad* collaborative teaching already exist at primary level and can serve as models for further implementation and expansion with soil (health) focus.

State and wishes of soil (health) education.

Purpose: The primary purpose of soil (health) education in Germany is to impart foundational knowledge and skills essential for addressing soil (health) conservation topics at later stages of education. The teaching materials cover topics such as soil formation, characteristics, degradation, conservation, and biodiversity (Reske-Hendler and Buchleiter, 2003). These resources primarily align with Mission Soil objectives of *reducing*

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soil pollution and enhancing restoration, *preventing erosion, improving soil structure to promote biodiversity*, and *improving soil literacy in society*. However, Mission Soil objectives related to *reducing desertification, conserving soil organic carbon stocks*, and *reducing the EU's global footprint on soils* are weakly or not integrated, possibly due to their complexity for primary level education focused on building foundational knowledge or their relevance to Germany (e.g., desertification). Educational materials also present how soil (health) contributes to SDGs, primarily addressing *zero hunger, quality education, clean water and sanitation, industry, innovation and infrastructure, sustainable cities and communities, responsible consumption and production, climate action,* and *life on land* (Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz, 2021 a & b; Ministerium für Umwelt und Verbraucherschutz des Saarlandes (MUV), 2020). Other SDGs are absent. Practical learning materials from the Ministry for Urban Development and the Environment (Behörde für Stadtentwicklung und Umwelt (Hrsg.), 2009) offer guidance on creating soil profiles and conducting experiments to reinforce understanding. The wishes are to strengthen the EU Mission Soil goal of *reducing soil pollution and enhancing restoration* and the SDGs that are already strongly embedded.

. A review of elementary school curricula across three federal states in Germany reveals that in terms of human development, the purpose of soil (health) education is predominant focussed on *knowing* (Ministerium für Umwelt und Verbraucherschutz (Hrsg.), 2023), supplemented by some *doing (*information.medien.agrar e.V., 2013b). The purpose of *being*, is generally not emphasized at the primary school level (Niedersächsisches Kultusministerium, 2021; Landesamt für Schule und Bildung Freistaat Sachsen, 2019). However, Staatsinstitut für Schulqualität und Bildungsforschung München, (2024) encourages students to recognize the mutual impact of nature and human activities, particularly in agriculture. This recognition is intended to foster a responsible and sustainable approach to nature and the environment. The wish is to strengthen the purpose of *knowing* amongst primary school students.

Collaboration: Collaboration in soil (health) education is predominantly *narrow*, and occasionally *narrow-broad*. While there are educational materials developed by the collaboration of different stakeholders, they often involve parties from similar sectors with similar themes, and therefore, these materials are developed under *narrow* collaboration. Furthermore, these resources are typically intended for classroom implementation by teachers (Ministerium für Umwelt und Verbraucherschutz, 2023), emphasizing their narrow focus within educational settings. The wish is to expand the collaborations to *narrow-broad* and *broad*.

Space: A review of educational materials indicates that soil (health) education in primary schools predominantly occurs *indoors*, supplemented by *outdoor* components. *Indoor* learning is primarily following a knowing-based approach and involves resources like worksheets on soil (health) topics, e.g., soil animals and layers (Ministerium für Umwelt und Verbraucherschutz, 2023). The *outdoor* educational components feature excursions and hands-on activities such as composting and studying earthworms (Aha

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Abfallwirtschaft Region Hannover, 2009; Ministerium für Umwelt, Landwirtschaft, Natur- und Verbraucherschutz des Landes Nordrhein-Westfalen, 2020). The wish is to strengthen *outdoor* education to compliment *indoors* education for soil (health).

Process: Soil (health) education for primary schools in Germany is primarily facilitated through *instructive* process with some components of *emancipatory* processes. *Emancipatory* processes in soil (health) education are typically outdoor oriented and involve experiential learning and student participation. However, the educational materials reviewed often prioritize structured guidance (*instructive*)over fostering open learning processes, despite advocating for learning through direct experience (Reske-Hendler & Buchleiter, 2003). For instance, the curriculum for 'Sachunterricht,' a subject in Saxony's elementary schools that introduces students to scientific, technical, social, economic, and historical aspects of their home region, emphasizes hands-on activities and field trips to foster independent understanding of the world. This approach supports more emancipatory learning processes but depends largely on teachers' implementation (Landesamt für Schule und Bildung Freistaat Sachsen, 2019). The wish is to create primary focus on *emancipatory* processes in soil (health) education.

Activities: In the primary education, soil (heath) education is facilitated by a combination of *knowing-based* activities, which is often complimented by *doing-based* activities to reinforce the knowledge. For example, the teaching material collection from the Saarland Ministry for the Environment and Consumer Protection uses worksheets to guide students (*instructive*) through experiments (*doing-based activities*), such as investigating the composition of soil (*Ministerium für Umwelt und Verbraucherschutz des Saarlandes, 2020*). Review of educational materials did not indicate presence of *being-based* activities. Contemplating desired activities, an interviewee expressed an interest in collaboration with scientists, advocating for partnerships where experts visit schools, thereby directly facilitating access to specialized knowledge for the students.

Paradigm: A review of soil education resources for primary schools indicates a greater emphasis on *mechanistic* paradigm, with specific focus on learning about the scientific basis of soil components and functioning, and their interactions within the ecosystems. There is little attention to the role of soil (health) for human and societal impacts (e.g. Reske-Hendler et al., 2003). The wish is to establish the *ecological* paradigm.

Gaps, challenges & opportunities

Soil (health) education at primary level in Germany is primarily focussed on providing the basic information about soil, and the broader connections between soil (health), ecosystem and human well-being are not emphasised. Furthermore, there are lack of activities that encourage students to explore and develop their personal connection to the soil (health). To realise the wishes to approach soil (health) education at primary level from an ecological paradigm, facilitated through *emancipatory* methods and incorporating *knowing-, doing-*, and *being-based* activities, several challenges need to be addressed. Firstly, teachers find the typical 45-minute session format insufficient for incorporating *outdoor* lessons or facilitating project-based *emancipatory* teaching. In addition, the teaching schedule is

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generally packed, leaving teachers a little scope for incorporating extra topics. Incorporating outdoor education is further constraint by lack of assess to suitable learning spaces and financial support for such activities. Given that many children, especially in urban areas, have little experience spending time in nature and interacting with soil, some may feel uncomfortable with certain outdoor activities. Therefore, it is necessary to establish specific guidelines that address these special cases, as well as health and safety concerns. Overcoming these challenges requires collaborative efforts among educators, policymakers, and community stakeholders to develop and implement soil (health) educational resources. Enhancing teacher training and support is also crucial to ensure effective integration of soil education across all subjects, thereby achieving broader sustainability and environmental goals. In the current design of primary education in Germany, there are clear opportunities to integrate soil (health) topics within existing curriculum subjects. The interviews revealed successful examples, though limited, where educators were able to integrate both doing- or *being-based* activities and *narrow-broad* collaborative teaching in primary education. These examples present models that can be replicated and expanded upon to create more well-rounded learning experiences.

> The problem is, in Sachkunde [science lessons], you feel you want to cover everything in primary school.
> *-A primary school teacher (from interviews).*

Secondary education

Vision: To broaden the scope of soil (health) education in integrate broader ecological and human systems with a focus on sustainability, and to engage more stakeholders in the education process.
Needs: To encourage and foster collaborations between educators, policymakers, and other stakeholders.
Opportunities: Interest in collaborating for soil (health) educations presents an opportunity to engage different stakeholders to bring in multidisciplinary and multisectoral perspectives on soil (health).

State and wishes of soil (health) education.

Purpose: The primary purpose of soil (health) education at secondary level in Germany is to create a foundational understanding of soil (health), on which soil (health) conservation topics can be taught at later stages of education. The curriculum covers a range of topics that include genesis, characteristics, and functions of soil (Reske-Hendler & Buchleiter, 2003), as well as the impact of anthropogenic activities, soil degradation, erosion and compaction (Ökologische Agrarwissenschaften Uni Kassel, 2014). Teaching materials also cover the soil in context of soil-biodiversity, agriculture and sustainable land management practices (information.medien.agrar e.V., 2013b). These address several Mission Soil objectives including- *reducing desertification, reducing soil pollution and enhancing restoration, preventing erosion, improving soil structure to enhance soil biodiversity* and *improving soil literacy in society.* The EU mission goals of *reducing desertification, conserving soil organic carbon stocks, and reducing the EU global*

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footprint on soils are weakly embedded or absent, presumably due to their perceived complexity (e.g., EU's global footprint) or perceived lack of regional relevance (e.g. desertification).

These teaching materials also present the connections between soil (health) and certain SDGs, specifically *zero hunger* and *responsible consumption and production* (emphasising connection to agriculture, food production, and drought), *quality education*, *clean water and sanitation* (in context of soil functions of filtering water), industry, *innovation, and infrastructure* (emphasizing connections to agriculture and land use), *sustainable cities and communities* (emphasizing connections to land use), *climate action*, and *life on land* (emphasising soil as essential for life and habitat for soil organisms like earthworms) (Behörde für Stadtentwicklung und Umwelt, 2009; Freie Universität Berlin, 2023; Bundesanstalt für Landwirtschaft und Ernährung, 2018; Ökologische Agrarwissenschaften Uni Kassel, 2015). Other SDGs such as *no poverty*, *gender equality*, *life below water, peace,* and *partnerships for the goals* are absent. The wish is to embed more Mission Soil objectives and SDGs with specific emphasis on *climate actio*n.

In terms of human development, the soil (health) education is predominantly focused on *Knowing* about soil (health) processes and is supplemented by (*doing*). Review of educational materials show primary focus is to gain understanding about a range if soil (health) related topics that include soil processes and soil biodiversity Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit, 2015). The priority placed on knowledge acquisition is expected to establish a basis for subsequent actions (*doing*) (Niedersächsisches Landesinstitut für schulische Qualitätsentwicklung, 2024). Examples of practical learning includes composting in school gardens and analysis of soil samples (information.medien.agrar e.V., 2013a; Ministerium für Kultus, Jugend und Sport, Ministerium für Ländlichen Raum und Verbraucherschutz, 2011). The purpose of *being* is further weakly embedded. No insights in the wishes on this aspect could be gained.

Collaboration: Collaboration in soil (health) education at secondary level in Germany is predominantly *narrow*, and occasionally *narrow-broad*. While there are educational materials developed by collaboration of different stakeholders, they often involve parties from similar sectors with similar thematic focus and, therefore, these materials are developed under narrow collaboration. Furthermore, these resources are typically intended for classroom implementation by teachers (Hellberg-Rode, 2002-2004), emphasizing their *narrow* focus within educational settings. There are examples where teachers collaborate for practical activities (Koordinierungsstelle für Umweltbildung in Neukölln beim Freilandlabor Britz e.V., 2024; Schullandheim Mittelfranken e.V., 2024). While conducting tests or experiments during regular school lessons is feasible, partnering with external entities requires additional time and coordination. This is why there are very few examples of cooperation in everyday school life, and therefore, there is a need to identify who could be considered as a potential partner. No insights on the wishes for collaboration could be gained.

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Space: A review of educational materials indicates that soil (health) education in secondary schools predominantly occurs *indoors*, supplemented by *outdoor* components. *Indoor* learning primarily adopts a knowledge-based approach and utilizes resources such as worksheets focused on soil topics. In these activities, students engage in researching and explaining the significance of soil resources for animals, plants, humans, and water balance, using soil as a specific example (Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit, 2015). *Outdoor* educational activities include hands-on tasks like composting and studying earthworms (information.medien.agrar e.V. (2013). No insights on the wishes for learning space could be gained.

Process: Revision of the guidelines for secondary education curricula in relation to soil (health) do not explicitly specify whether the approach should be *instructive* or *emancipatory*. Nevertheless, these guidelines are often detailed and specific, indicating the preference for *instructive* processes, which are primarily focused on teaching basic facts about soil (health). *Emancipatory* processes are mainly integrated into outdoor education to supplement the knowledge acquisition. For example, in Lower Saxony, the curriculum emphasizes developing knowledge related to specific topics such as soil functions (Niedersächsisches Landesinstitut für schulische Qualitätsentwicklung, 2024). This emphasis is reflected in the content and learning materials designed to facilitate the acquisition of these skills in a structured manner (e.g., Reske-Hendler et al., 2003). Outdoor activities frequently combine *instructive* and *emancipatory* processes, such as field excursions with a specific focus (Niedersächsisches Kultusministerium, 2014). No specific wish could be identified apparently due to satisfaction with the existing state.

Activities: In the Secondary education, soil (heath) education is facilitated by a combination of *knowing-based* activities, which is often complimented by *doing-based* activities to reinforce the knowledge. For example, the teaching materials from the Department for Urban Development and the Environment (Behörde für Stadtentwicklung und Umwelt, 2009) provides worksheets to guide students through tests and experiments, such as examining soil composition, soil profiles and functions. Review of educational materials did not indicate presence of b*eing-based* activities. No insight on the wishes for activities were gained.

Paradigm: A review of soil education resources for secondary schools indicates a greater emphasis on *mechanistic* paradigm, with specific focus on learning about the scientific basis of soil components and functioning, and their interactions within the ecosystems. There is little attention to the role of soil (health) for human and societal impacts (e.g. [Reske-Hendler et al., 2003). Although, no concrete wishes were mentioned, one statement suggests a wish for an ecological approach, applying a systemic perspective to ensure that it and its related learning processes foster a systemic understanding.

Gaps, challenges & opportunities

The secondary level soil (health) education in Germany is approached from a predominantly *mechanistic* paradigm which is primarily focussed on providing the basic information about soil. There is little encouragement on exploring personal connections to the soil as well as a

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notable gap in emphasizing broader connections between soil (health), ecosystems, and human well-being. There seems to be a general satisfaction with the current educational design and concerns regarding finding the balance across mechanistic and ecological paradigms, and instructive and emancipatory processes that fits within the current educational design and goals.
There are opportunities to expand collaborations in soil (health) education, by fostering collaborative efforts among educators, policymakers, and community stakeholders to enhance soil (health) education resources. One challenges is the availability of regional collaborators. This potentially could be addressed by pooling expertise and resources, accompanied by developing comprehensive educational materials and programs for effective implementation.

Tertiary education

Vision: To broaden the scope of soil (health) education to include all Mission Soil objectives and SDGs. To anchor soil (health) education solidly in fare more degree programs, relative to the past.
Needs: To encourage collaborations and include multiple stakeholders concerning soil (health) in soil (health) education. To initiate change of perspective by engaging learners and stakeholders from multiple sectors in a comprehensive dialogue
Opportunities: The universities are seen as having a responsibility as well as the capacities in teacher training to mediate between schools and landowners in order to establish extracurricular learning sites.

State and wishes of soil (health) education.

Purpose: At the tertiary level, the extent to which soil (health) education is integrated into the courses depends very much on the degree program. Even at Master's level in degree courses related to sustainable transformation, it is possible that soil (health) is at best a marginal topic. Educational materials typically cover a wide range of topics including soil structure, classification, composition and characteristics as well as the studying the soil (health) and functions within the context of with botany and agriculture, and sustainable soil management practices for example in the course "L011 – Bodenkunde" [Pedology] (Hochschule für Forstwirtschaft Rottenburg, 2018, Hochschule für Technik und Wirtschaft Dresden, 2024). These educational materials address Mission Soil objectives of *conserving soil organic carbon stocks, reducing soil pollution and enhancing restoration, preventing erosion, improving soil structure to foster biodiversity, and enhancing soil literacy within society*. For instance, the Environmental Engineering program at the University of Darmstadt includes modules covering basic soil science, soil protection, and practical fieldwork related to erosion, soil compaction, soil sealing, and soil evaluation (Hochschule Darmstadt, 2019). Goals of *reducing desertification* and *reducing the EU global footprint on soils* were found to be missing in the courses reviewed in this research.

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The educational materials also address the SDGs of *zero hunger,* responsible consumption and production and *industry, innovation and infrastructure* (by emphasising connections with agriculture), *quality education* (as implied by the inclusion of soil (health) topics in the curricula), *clean water and sanitation* (by emphasising the functions of soil in regulating clean water supply), *climate action* (by emphasising the role of soil conservation in climate change mitigation), and *life on land*. Broader SDGs especially those that primarily seem to address socio-economic issues such as *no poverty, decent work and economic growth, justice and strong institutions* and *partnerships for the goals* were absent. Presumably, these goals are not considered relevant within the disciplinary focus. The wishes are to broaden the scope of soil (health) education so as to address all Mission Soil objectives and SDGs.

> I find this connection [between soil (health) and human health] very important, and to date it is not so present [in soil (health) education].
> *-A university student (from interviews).*

In terms of human development, the purpose of tertiary soil (health) education is predominantly on knowledge acquisition (*knowing*) with an assumption that knowledge will create the foundation for systems thinking and taking action (*doing)*. For instance, the module, "Altlasten und Bodenschutz" (Osnabrück University, 2024) targets master's students in landscaping, aiming to prepare them to implement soil (health)-conserving practices in their professional careers. The emphasis is on prioritizing knowledge acquisition to inform practical actions in the future. The purpose of *being* is weakly embedded. The belief that merely disseminating knowledge might be sufficient to promote the EU mission soil in terms of sustainable land and soil management is regarded with scepticism.

Collaboration: Soil (health) education at the tertiary level primarily involves *narrow* collaborations, occasionally extending to *narrow-broad* collaborations. *Broad* collaborations are rare. The wish is to cover various facets of soil (health)and to achieve this through communication that involves the farmer, the industry, the researcher, and the politician.

Space: Teaching materials are predominantly tailored for *indoor* education, primarily in classrooms. However, module handbooks do not provide specific instructions on implementation methods, suggesting that the decision to implement specific modules *indoors* or *outdoors* primarily rests with university lecturers. It greatly depends on the academic orientation of the degree program and the presence of a specialization in soil science, as well as its emphasis, whether students are offered learning opportunities outside the university The wish is to integrate indoor learning in seminar rooms, lecture halls, and laboratories with outdoor activities.

Process: Based on the review of course modules for tertiary level soil (health) education in Germany, there is an apparent predominance of *instructive* processes with a focus on knowledge acquisition rather than on the process of learning. This knowledge acquisition, however, likely enables the students to reflect upon and shape their behaviours according to their unidentified priorities. For instance, at the University of

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Neubrandenburg, students studying Agricultural Economics learn fundamental aspects of plant cultivation, including soil formation factors, soil types, water balance, organic components, and soil protection (Hochschule Neubrandenburg, 2024). This knowledge empowers them to independently apply these principles in practice. Emancipatory processes are apparently only weakly embedded. The wish is to actively engage learners by fostering an environment that encourages participation and interaction, enhancing communication and involvement with the subject matter. Consequently, there is a wish to integrate a more emancipatory approach into soil (health) education at the tertiary level.

Activities: At the tertiary level, soil (health) education combines *knowing-based* with minor components of *doing-based* activities such as data collection and taking soil profiles. For example, in a module at the University of Darmstadt (Hochschule Darmstadt, 2013), students first receive theoretical background information on soil profiles (*knowing-based* activity), followed by field work where they record and evaluate soil profiles (a *doing-based* activity). *Being-based* activities are very weakly embedded or absent from most courses. The wish is facilitating connections between people and the soil, as well as fostering interpersonal connections. to avoid a lack of communication between different groups, such as researchers and farmers, or between the general public and professionals in the field. Regardless of one's—be it a researcher, a farmer, a student, or just an ordinary citizen—the goal is to begin creating a network of connections. Essentially, it's about bridging gaps and building relationships to enhance understanding and collaboration amongst diverse groups to promote a shared interest in soil and environmental stewardship.

Paradigm: In tertiary level soil (health) education, *mechanistic* paradigm dominates. Many modules address subject-specific content without delving deeper, and those where soil (health) related content is contextualized within a broader framework, there is little focus on socio-ecological aspects. *Ecological paradigm* is weakly embedded and there are only a few examples. For instance, a module at the University of Bremen includes the topic titled: "Why should we care about ecosystems? Biodiversity as an environmental protection task" (Hochschule Bremen, 2021). A wish for this aspect is a comprehensive treatment of the multitude of perspectives on soil (health), integrated into the study program in a highly systematic manner, taking an overall approach.

Gaps, challenges & opportunities

At tertiary level soil (health) education in Germany, educational offers tend to focus on covering foundational theories and knowledge related to soil (health) topics. There is a distinct lack of opportunities for students to apply this knowledge practically. This gap along with the lack of activities that encourage exploring personal connections to soil (health) potentially limits their ability to effectively address soil (health) issues in real-world context.

> Soil is actually something so fascinating… These are all important topics [connection between soil (health) and SDGs] that are neglected.
> *-A university student (from interviews).*

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To address this, the educational materials need to present soil (health) education within the context of broader ecological and socio-economic connections contexts (*ecological paradigm*). However, there are concerns on the finding the balance across *mechanistic* and *ecological paradigms* that fits within the goals of the educational outcomes. Being able to do this would also enable realizing the wishes to embed all SDGs within soil (health) education. In addition, there is a need to increase stakeholder collaboration with universities that would support the skill development in real-world context as well as bringing in the multiple perspectives around soil (health). A prerequisite in regard to the linkage of various stakeholders is adequate communication, that is comprehensible to all parties involved.

Vocational educational training (VET)

Vision: To strengthen soil (health) related topics within VET courses and expand the scope to integrate all Mission Soil objectives and SDGs with a greater emphasis on the purpose of *doing*.
Needs: To present soil (health) related topics within broader ecological and socioeconomic contexts and strengthen the practical skills development that meets student's professional needs.
Opportunities: Existing programs such as the teaching proposal from the Federal Agency for Agriculture and Food (Bundesanstalt für Landwirtschaft und Ernährung et al., 2023) that emphasize hands-on learning serve as a potential model for expanding such initiatives to promote a more *doing* focussed education.

State and wishes of soil (health) education.

Purpose: At the VET level, soil (health) education apparently focusses on providing the basic knowledge and on improving students' soil-related skills. The educational materials focus on the topics of soil fertility such as carbon and phosphorus cycling, challenges soil face such as erosion and compaction, importance of soil in agriculture and soil management practices (e.g., sludge, biochar, compost applications, cultivation equipment's). These materials also address soil (health) topics within broader contexts of global connections, human intervention in ecosystems and legal foundations. For instance, the curricular requirements of the federal state of Bavaria specify that students should engage with soil (health) topics in agriculture, covering conventional and organic farming, good professional practices such as integrated crop protection, wide crop rotation, closed farm cycles, green manure, and legumes (Staatsinstitut für Schulqualität und Bildungsforschung München, 2024). These materials address the Mission Soil objectives of *conserving soil organic carbon stocks, reducing soil pollution and enhancing restoration, prevention erosion, improving soil structure to enhance soil biodiversity,* and *improving soil literacy in society.* However, the goals of *reducing desertification, stopping soil sealing and increase re-use of urban soils* and *reducing the EU global footprint on soils* are not addressed presumably because these seemingly do not align with the course contents and objectives. The educational materials on soil (health) at VET level, present the connections of soil (health) with SDGs of *zero hunger, industry, innovation and*

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infrastructure and *responsible consumption and production* (by emphasising the connections with agriculture), *quality education* (implied by the inclusion of soil-related topics in the curricula), *climate action* (by emphasising the connections with human intervention in ecosystems and soil conservation strategies) and *life on land* (by emphasising the connections with animal welfare in agriculture and plant protection). For instance, the curricula requirements of the federal state of Bavaria, mandates that students learn about environment friendly measures in agriculture (Staatsinstitut für Schulqualität und Bildungsforschung München, 2024). Broader SDGs especially those that primarily seem to address socio-economic issues such as *no poverty, decent work and economic growth* and *partnerships for the goals* were absent. The wishes are to make the connections between soil (health) and all SDGs more explicit within relevant VET courses, with a special emphasis on *climate action, life on land* and *life below water* and however, the concerns on how to match all SDGs with the thematic focus of various courses were also raised.

In terms of human development, the purpose of VET level soil (health) education is predominantly on knowledge acquisition (*knowing*) with an assumption that knowledge will create the foundation for systems thinking and taking action (*doing*). For instance, the curricula in the federal state of Bavaria emphasizes knowledge acquisition about certain topics without mandating their practical implementation (Staatsinstitut für Schulqualität und Bildungsforschung München, 2024). However, some further training programs are designed for practical application (e.g. Landwirtschaftskammer Niedersachsen, 2024). The purpose of *being* is largely absent from the curricula, except a brief mention that students should understand human interventions in ecosystems and the global interweaving of material cycles (Staatsinstitut für Schulqualität und Bildungsforschung München, 2024). There is some wish to strengthen the purpose of *doing*.

Collaboration: Soil (health) education at the VET level primarily involves *narrow* collaborations, occasionally extending to *narrow-broad* collaborations. *Broad* collaborations are rare. Although there are educational materials developed collaboratively by several stakeholders, they typically limited to similar sectors. However, here is a lack of information on the extent of implementation so such educational material. There is an apparent satisfaction from the state of collaboration in soil (health) education. Involving a wider range of stakeholders is not seen as particularly important, nor is considered realistic within current educational design.

> It has to be possible to reach the partner regionally [in context of collaboration]. *-A VET and secondary school teacher (from interviews).*

Space: Most soil (health) education related VET programs are designed to primarily take place *indoors* with some components of *outdoors*. For example, the teaching guideline from the Federal Agency for Agriculture and Food initially deals with knowledge structure and finally the practical application (Bundesanstalt für Landwirtschaft und Ernährung et al., 2023). There is an apparent satisfaction from the state of learning spaces employed in soil (health) education.

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Process: The curricula do not specify educational processes, leaving room for implementing both *instructive* and *emancipatory* approaches. In practice, however, *instructive* processes dominate in soil (health) education in VET programs. *Emancipatory* processes are weakly present and are primarily embedded within practical, hands-on learning activities. No specific wishes concerning the processes emerged.

Activities: At VET level, soil (health) education combines *knowing-based* with minor components of *doing-based* activities. For example, the educational material by the Federal Agency for Agriculture and Food (Bundesanstalt für Landwirtschaft und Ernährung, 2023) guides students to first learn about specific issues in agricultural soil management, and then perform soil examinations themselves. *Being-based* activities are very weakly embedded or absent from most courses except occasional references prompting students to question agricultural management methods (Bundesanstalt für Landwirtschaft und Ernährung, 2023). No specific wishes concerning the processes emerged.

Paradigm: In VET programs related to soil (health) education *mechanistic* paradigm dominates. Many modules address subject-specific content without delving deeper, and those where soil (health) related content is contextualized within a broader framework, there is little focus on socio-ecological aspects. For instance, in the practical seminars and workshops for educators and teachers titled "Soil, forest, water, air - experience, explore, protect," each subject area such as soil, forest, and air is predominantly addressed separately, with brief focus on their interactions with each other (Naturerlebnis und Umweltbildung in Hamburg, 2010).

Ecological paradigm is weakly embedded and there are only a few examples. For example, the curricular guidelines for the state of Bavaria touches upon the ecological paradigm, requiring students to comprehend "human interventions in the global interweaving of material cycles and their consequences" and "human interventions in ecosystems" (Staatsinstitut für Schulqualität und Bildungsforschung München, 2024). No specific wishes concerning the paradigms emerged.

Gaps, challenges & opportunities

At VET level educational offers in Germany tend to focus on covering the knowledge and some practical skills related to soil (health) topics. There are lack of activities that encourage exploring personal connections to soil (health) potentially limits their ability to effectively address soil (health) issues in real-world context. There is apparent satisfaction with the current states of collaborations and learning spaces employed in soil (health) education, and no explicit wishes concerning the dimensions of process, activities and paradigms. There are however, wishes to strengthen the soil (health) related topics within VET courses with a stronger purpose of *doing*, and to integrate all the Mission Soil objectives and the SDGs.
To realize these wishes, soil (health) topics need to be presented within the broader ecological and socio-economic contexts, we well as making them relatable to the students' professional needs and social life. However, there are concerns regarding achieving a balance between mechanistic and ecological paradigms that align with educational goals.

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Designing and implementing soil (health) education with a focus on practical application should therefore be carefully considered to meet professional future needs.

General public

Vision: To enhance soil (health) awareness in society by emphasizing the importance of healthy soils for ecological and human systems without narrowly focusing on specific EU mission goals, SDGs, or human development aspects.
Needs: To enhance accessibility, engagement, and inclusivity of soil (health) educational resources, adopt a simple language and create educational materials that integrate foundational knowledge and practical skills within broader ecological contexts.
Opportunities: There is an opportunity to expand upon existing public interest in soil (health) and resources focused on soil (health), as well as citizen science projects.

State and wishes of soil (health) education.

Purpose: Extensive educational materials on soil (health) topics are available to the general public (e.g. soil brochure (Ministerium für Energiewende, Landwirtschaft, Umwelt und ländliche Räume des Landes Schleswig-Holstein, 2015), a video on the consequences of soil sealing (Hessischer Rundfunk, 2021), and the Federal Soil Protection Act (Bundes-Bodenschutzgesetz, 2021)-a law aimed at protecting soil against harmful changes and restoration of contaminated soils (Gesetz zum Schutz vor schädlichen Bodenveränderungen und zur Sanierung von Altlasten, Bundes-Bodenschutzgesetz - BBodSchG). The depth of coverage can vary significantly across specific topics. For instance, the YouTube channel, 'Simple Club' offers educational videos on basic soil topics like Humus (Geographie – simpleclub, 2017). Legal frameworks, such as the EU Soil Framework Directive, establish requirements and measures for soil protection (Richtlinie des europäischen Parlaments und des Rates zur Schaffung eines Ordnungsrahmens für den Bodenschutz und zur Änderung der Richtlinie 2004/35/EG, 2006). Organizations such as OroVerde addresses monocultures and agroforestry systems (OroVerde – Die Tropenwaldstiftung, 2023). The education materials cover a diversity of topics that include monocultures, rainforest protection, soil types, formation and functions as well as soil-climate interactions, legal aspects of soil conservation and sustainability measures.
These educational resources address most of the EU Mission Soil objectives except the three goals-*reducing desertification, conserving soil organic carbon stocks,* and *reducing the EU global footprint on soils* that are weakly or not embedded.
These educational materials also address several SDGs that include *zero hunger, responsible consumption and production, industry, innovation and infrastructure,* and *sustainable cities and communities* (by emphasising the connections with agriculture, soil conservation and construction), *quality education* (implied by the inclusion of soil (health) related topics), *climate action* (by emphasising the connections with rainforest protection and climate change mitigation), and *life on land* (by emphasising the connections with plants). Broader SDGs especially those that primarily seem to address socio-economic issues such as *no poverty, decent work and economic growth* and

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partnerships for the goals were absent. The wish is to strengthen the goals of *reducing soil pollution and enhancing restoration, responsible consumption and production, decent work and economic growth* and *partnerships for the goals.*
In terms of human development, the purpose of soil (health) education for general public is predominantly on knowledge acquisition (*knowing*) with an assumption that knowledge will create the foundation for systems thinking and taking action (*doing*). There are some examples that are more focused on *doing*, for instance recommendations for stakeholders who want to take action in this field (Niedernostheide et al., 2015). The purpose of *being* is largely absent. There is apparent satisfaction with predominant focus on the purpose of *knowing*.

Collaboration: The soil (health) related education for the general public is predominantly offered through *narrow* collaborations. While there are some educational materials developed collaboratively by several stakeholders, these collaborations are often limited to similar sectors (e.g., Bundesverband Boden e.V. 2024). Occasionally, collaborations take a *narrow-broad* approach, while *broad* collaborations are rare. The wish is to make the collaborations *broad* with engagement of diverse stakeholders in soil (health) education.

Space: Educational resources available to general public are primarily designed for *indoor* learning (e.g., at home) and include YouTube videos (Klimabuendnis, 2020), magazines (Fraedrich et al., 2022), and other information materials (Ministerium für Klimaschutz, Umwelt, Energie und Mobilität des Landes Rheinland-Pfalz, 2024). The outdoor components are weak and include examples of participation in activities such as educational trails (Stadt Wuppertal, 2014). No insights on the wishes for learning space could be gained.

Process: Soil (health) awareness offers for general public are predominately facilitated through *instructive* processes with components of *emancipatory* processes. For example, the educational material, 'Boden – der Grund auf dem wir leben' (Bayerisches Landesamt für Umwelt, 2023) resents an example of *instructive* approach, whereas educational trails (e.g. Stadt Wuppertal, 2014) presents an example of *emancipatory* approach. The wish is to facilitate soil (health) education for general public through a combination of *instructive* and *emancipatory* processes.

Activities: In soil (health) awareness offers for general public, the *knowing-* and *doing-based* activities prevail. For example, the educational film "Der Boden ist ein lebender Organismus" by Planet Health Cure BV (2017) is a *knowing-based* activity, whereas trails offered by organizations like the Nature Conservation Association (Naturschutzbund Deutschland e.V., 2024) employ more *doing-based* activities. *Being-based* activities are found to be absent. The wish is to adopt activities that have stronger components of *doing-* and *being-based* activities.

Paradigm: A review of available soil (health) awareness offers for general public indicate a predominance of *mechanistic* paradigm and focus in educating about the specific soil components and functioning (e.g. Deutsches GeoForschungszentrum, 2019) with limited emphasis on the broader connections with ecological and human systems. This

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ecological paradigm is weakly embedded. Predominance of ecological paradigm is wished for soil (health) education for general public.

Gaps, challenges & opportunities

In Germany, there are several resources for soil (health) education available to the general public, however, there is need of increasing the outreach, with a special focus on reaching individuals with no prior interest in soil (health). To realise the wishes to transition to approach soil (health) education from an *ecological* paradigm and facilitate using a combination of *instructive* and *emancipatory* processes with stronger components of *doing-* and *being-based outdoor* activities, there are certain challenges that need to be addressed. At core, there is need to create educational materials that are engaging and relatable to the learners, as well as enabling the action and behavioural change to propose soil (health). In this direction, lack of *emancipatory* processes in the educational resources, coincides with the lack of *outdoor* educational activities which limits the opportunities for transformative educational experiences that could enable behavioural change to promote soil (health) conservation. To address these challenges, there is a need to address administrative hurdles (e.g. regarding safety concerns during outdoor education) and funding requirements (e.g. to enable outdoor learning and to continue the projects).

> If you want to achieve this [sustainability] in the long term, then you have to formulate guidelines and regulations that force people to adhere to them.
> *-A university professor (from interviews).*

Realisation of the wish of *broad* collaborations for soil (health) education faces a significant hurdle, as there is a notable gap in cross-sector collaboration and engagement of diverse stakeholders, which also impedes integrating all the SDGs. Moreover, developing Comprehensive Educational Materials is essential to provide resources that not only cover basic soil (health) concepts but also place them within broader ecological and social contexts, ensuring a comprehensive understanding among learners.

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A.3. Greece

Soil (health) education in Greece across all levels of formal education shares a general focus on the relationship of soil (health) with sustainability and food production. Across all formal education levels, there is an emphasis on developing practical knowledge and skills, and educational approaches predominantly rely in *instructive* processes that employ *knowing*- and *doing-based* activities predominantly conducted *indoors*. However, at primary and secondary education, school gardens serve an important learning space that presents students with real-life experiences. The broader integration of the EU Mission Soil objectives and Sustainable Development Goals (SDGs) into the curriculum is generally weak. The purpose of soil (health) education in Greece also predominantly is focused on the aspects of *doing* and *knowing*, with a little to no encouragement on exploration of ones own relationship and critical thinking around soil (health)-the aspect of *being*. Tertiary education, particularly in agricultural sciences, covers the EU Mission Soil more comprehensively but still falls short in integrating broader SDGs. For general public, the opportunities for soil (health) education are non existent and those that do have a limited focus on agriculture. There is a need to engage broader stakeholders especially the government and NGOs which to create such offers, and expand them beyond the agricultural sectors.

Primary education

Vision: To teach young students the role and functions of the soil as a living organism that needs constant attention
Needs: Soil (health) at the primary education level in Greece should focus more on *doing*.
Opportunities: To use and expand the existing school gardens to provide real-life experiences and hands on techniques regarding soil (health).

State and wishes of soil (health) education

Purpose: In primary school curriculum in Greece, the purpose of soil (health) education is to raise awareness ion the importance of healthy soils and to create an understanding of natural systems, specifically in relation to the provisioning of food. Therefore, EU Mission Soil's goal of improving soil literacy in society is prominent, while other Mission Soil objectives and SDGs are not embedded.

In terms of human development, the *doing* appears the main purpose. Primary schools in Greece use school gardens to provide real-life experiences and hands on techniques for teaching various subjects including science, math, nutrition and environmental education. With an aim to nurture a responsibility towards environment School gardens also play important role in promote in teaching about soil (health) and its role in food production. However, the personal experience is often missing and the purpose of *being* is not embedded in primary education. *Knowing* is weekly embedded as the national curriculum in

> Soil (health) is a complex and specialized subject that might not be widely understood, even among educators. Without sufficient training and resources, teachers may feel unequipped to address this topic in the classroom.
> *-A university lecturer (from focus group).*

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Greece, tends to prioritize subjects that are seen as foundational, such as mathematics, language arts, and science in a broader sense. Environmental education, and specifically soil (health), is not given the same emphasis. No insights on the wishes on this aspect could be gained.

Collaboration: Review of educational materials indicate that the collaboration is primarily narrow at primary education level in Greece. *Narrow-broad* and *broad* collaborations are absent. No insights on the wishes on the aspects of purpose could be gained.

Space: Soil (health) education in primary schools in Greece is primarily conducted *indoors* inside classroom with some components of *Outdoor* in school gardens. No insights on the wishes on this aspect could be gained.

Process: Soil (health) education for primary schools in the Greece are primarily facilitated through *instructive* processes, relying on pre-defined knowledge, teacher explanation and assessments and making use of resources such as books, textbooks, films, etc. *Emancipatory* processes are missing. No insights on the wishes on this aspect could be gained.

Activities: Soil (health) education for primary schools in the Greece are primarily facilitated through knowing-based activities. *Being-based* activities or activities that incorporate *knowing*, *doing* and *being* were found to be absent. *Doing-based* activities are weekly embedded in the Greek schools due to lack of adequate resources. No insights on the wishes on this aspect could be gained.

Paradigm: A review of soil education resources for primary schools indicates a dominance of *mechanical* paradigm while the *ecological* paradigm is very weekly embedded. No insights on the wishes on this aspect could be gained.

Gaps, challenges & opportunities

Soil (health) education in primary schools in Greece lacks presenting the role of soil (health) in connection to SDGs and Mission Soil objectives. While, there is an apparent goal of improving responsibility towards environment and widespread use of school gardens for hand-on learning in a variety of subjects, comprehensive soil (health) education is largely absent and teaching approach remains instructive with absence of collaborations (Chatzifotiou 2015).

> There is a lack of strong advocacy from environmental organizations or experts specifically focused on integrating soil (health) into educational materials. Without pressure from knowledgeable groups, it is less likely that curriculum developers and educational authorities will prioritize this topic.
> *-A primary school teacher (from interviews).*

Secondary education

Vision: To move the education to towards a holistic knowledge and understanding of the soil as a living organism

Needs: soil (health) education at the secondary level in Greece should focus more on *doing*.

Opportunities: to use and expand the existing school gardens to provide real-life experiences and hands on techniques regarding soil (health).

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State and wishes of soil (health) education

Purpose: In primary school curriculum in Greece, the purpose of soil (health) education is to raise awareness ion the importance of healthy soils and to create an understanding of natural systems, specifically in relation to the provisioning of food. Therefore, EU Mission Soil's objectives of improving soil literacy in society is prominent, while other objectives and SDGs are not embedded.

In terms of human development, the *doing* appears the main purpose. Primary schools in Greece use school gardens (where available) to provide real-life experiences and hands on techniques for teaching various subjects including science, math, nutrition and environmental education. With an aim to nurture a responsibility towards environment School gardens also play important role in promote in teaching about soil (health) and its role in food production. However, the personal experience is often missing and the purpose of *being* is not embedded in primary education. Knowing is weekly embedded as the national curriculum in Greece, tends to prioritize subjects that are seen as foundational, such as mathematics, language arts, and science in a broader sense.

> The national curriculum in Greece tends to prioritize subjects that are seen as foundational, such as mathematics, language arts, and science in a broader sense. Environmental education, and specifically soil (health), are not given the same emphasis.
> *-A university professor (from focus group).*

Environmental education, and specifically soil (health), is not given the same emphasis. No insights on the wishes on this aspect could be gained.

> Developing and distributing specialized educational materials requires investment and collaboration between educators, government bodies, and environmental organizations. In Greece, educational resources tend to be limited, and available funds are directed towards more traditional subjects or broader environmental education, rather than the specific topic of soil (health).
> *-A hIgh-school teacher (from interviews).*

Collaboration: Review of educational materials indicate that the collaboration is primarily narrow at primary education level in Greece. *Narrow-broad* and *broad* collaborations are absent. No insights on the wishes on the aspects of purpose could be gained.

Space: Soil (health) education in primary schools in Greece is primarily conducted *indoors* inside classroom with some components of *Outdoor* in school gardens. No insights on the wishes on this aspect could be gained.

Process: Soil (health) education for primary schools in the Greece are primarily facilitated through *instructive* processes, relying on pre-defined knowledge, teacher explanation and assessments and making use of resources such as books, textbooks, films, etc. *Emancipatory* processes are missing. No insights on the wishes on this aspect could be gained.

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embedded in the Greek schools due to lack of adequate resources. No insights on the wishes on this aspect could be gained.

Paradigm: A review of soil education resources for primary schools indicates a dominance of *mechanical* paradigm while the *ecological* paradigm is very weekly embedded. No insights on the wishes on this aspect could be gained.

Gaps, challenges & opportunities

Soil (health) education in primary schools in Greece lacks presenting the role of soil (health) in connection to SDGs and Mission Soil objectives. While, there is an apparent goal of improving responsibility towards environment and widespread use of school gardens for hand-on learning in a variety of subjects, comprehensive soil (health) education is largely absent and teaching approach remains instructive with absence of collaborations.

Tertiary education

Vision: To prepare the future soil professionals with the knowledge and skills to sustainably manage soil (health) that align with the sustainability goals.
Needs: To integrate the connections to wider SDGs and develop approaches that focus on knowing, doing, and being in soil (health) education related courses.
Opportunities: Existing educational infrastructure, such as soil science laboratories can be used to implement some of the desired changes that include strengthening of doing-based activities.

State and wishes of soil (health) education

Purpose: At the tertiary level, the depth, perspectives and approach to soil (health) education depends upon the scientific field. Nevertheless, the national universities in Greece play an extended role in society and covers all the Mission Soil objectives to a degree (Kazamias & Sapountzis, 2017). For example, as part of the efforts to implement the 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT, Greece has been promoting sustainable economic growth through research and innovation (SDGs 8.2, 8.3, 9.5). For Greece, research, technological development and innovation (RTDI) lie at the core of the process of implementing the SDGs at national and regional level. Science and research has an essential function for the sustainable design of the economy and society. Research projects communicate new approaches and solutions to society. The Greek research community and its institutional landscape seem to fulfill many of the requirements for a productive knowledge base for a sustainable economic growth.

In its effort to cultivate a culture of dialogue and partnership, the Office of Coordination, Institutional, International and European Affairs of the General Secretariat of the Government (OCIIEA) encourages and facilitates, individually or in close cooperation with line ministries, the transparent and inclusive consultation with

> Environmental topics tend to focus on more visible issues like air and water pollution, climate change, and deforestation, with soil health being less immediately apparent to students and educators.
> *-A University professor (from focus group).*

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multiple stakeholders actively engaged in the SDGs implementation process (civil society and social partners, the private sector, academia and research community, regional and local authorities). A worth noting initiative that the OCIIEA took in cooperation with the Institute of Training of the National School of Public Administration and Local Government (EKDDA), is the introduction of a 3-day recurring seminar for the SDGs, where the senior public employees are trained at the international, European and national dimension of the SDGs. Thus, the employees from the ministries, local and regional administrations, universities, research centres and independent authorities who are enrolled for this seminar become fully aware of the core vision, priorities, objectives and multiple dimensions of the 2030 Agenda, and they add credits to their CV and personal career. Most importantly, they build a network of senior public employees with shared responsibility and commitment to implementing PCSD and SDGs across sectors and governance levels. Additionally, this network could contribute significantly to the submission of policy proposals and recommendations on SDG related issues and to the elaboration and drafting of key policy documents, such as national implementation plans for the SDGs and strategies. In addition to that, an innovative workshop for the implementation of the SDGs, with the participation of the major stakeholders will take place at the same institution.However, there is greater focus on the goals *to conserve soil organic carbon stocks, e*specially in agricultural sciences, where it is extensively covered (AUA, 2024; AUTH, 2024). In addition, the goal to *stop soil sealing and increase re-use of urban soils* in gaining greater focus specially in the context of sustainable rural development and the control of intensive urbanisation. There are now several practical applications related to land use and green development in purely urban environments. In addition, the goal of preventing erosion is also gaining focus in tertiary education (Kazamias & Sapountzis, 2017; AUA, 2024). The goals to *reduce the EU global footprint on soils* and *reduce desertification* are least embedded.

In terms of the SDGs, many universities focus on research related to industrial and innovative applications (UOP, 2024) thus addressing the SDG of *industry, Innovation and Infrastructure*. In recent decades, there is a gradual shift towards organic and sustainable agriculture that has caused tertiary education to increase focus on the SDGs of *zero hunger* and *responsible consumption and production* (Massas et al., 2023). However, the tertiary level soil (health) education in Greece also should to include the SDGs of *clean water and sanitation*, *climate action*, *life on Land* and life *below water* (Barbayiannis et al., 2011).

In terms of human development, the purpose of soil (health) education is predominantly on *doing* as the tertiary education in Greece places emphasis on skill development, especially in the fields of subjects that include agricultural sciences (AUA, 2024). Then purpose of *knowing* is also strongly embedded via educational activities that include lectures and practical courses (UOP, 2024). The purpose of *being* is weakly embedded. Desk research indicated the need to integrate the three aspects of the purpose—*knowing, doing* and *being* in the tertiary level soil (health) education to align with the current challenges concerning sustainability (AUTH, 2024).

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Collaboration: Soil (health) education at the tertiary level on Greece primarily involves *narrow* and *narrow-broad* collaborations and usually involves collaborators from the same sector or industry to disseminate practical and technological knowledge (Srivastava et al., 2017; Schismenos et al., 2022). *Broad* collaborations are rare which may be attributed to the fact that tertiary level focusses on specialized and specific scientific knowledge and applications around soil (health) education. This encourages collaboration between scientists and stakeholders single discipline (Efthimiou, 2020). The desk research indicated the need to broaden the vision of soil (health) education by transcending disciplinary boundaries and regional issues. This approach calls for collaboration across multiple disciplines and sectors, involving academics, industry professionals, company executives, NGO leaders, and others, extending beyond geographical and national borders.

Space: The predominant learning space for soil (health) education is *indoors*, primarily the classrooms and laboratories. Although weakly embedded, *outdoor* components such as field studies are increasing (AUA, 2024). No insights into the wishes for this aspect could be gained.

Process: There is predominance of *instructive* processes in tertiary level soil (health) education with a focus on the transfer of predetermined knowledge, skills, procedures, etc. to support learning in a predetermined direction. This educational approach follows two main axes: theoretical and practical. The theoretical component teaches students about soil characteristics and variables, and how these factors influence their field of study (Barbayiannis et al., 2011; AUA, 2024; AUTH, 2024). The *emancipatory* process is weakly embedded. No insights into the wishes for this aspect could be gained.

Activities: At the tertiary level, soil (health) education combines *knowing-based* activities like lectures, seminars and presentations, with *doing-based* activities like soil sampling and analysis in the laboratories, application of equipment and field trips. *Being-based* activities are very weakly embedded in soil (health) education likely due to the perception that interpersonal and socio-emotional aspects—such as contemplation, drawing, music, and play—are less significant in soil (health) education at tertiary level. No insights into the wishes for this aspect could be gained.

Paradigm: In tertiary level soil (health) education, *mechanistic* paradigm dominate. *Ecological paradigm* is weakly embedded. Desk research suggests to integrate *mechanistic* and *ecological paradigms* for an ideal soil (health) education.

Gaps, challenges & opportunities

Currently there is an insufficient integration of SDGs in tertiary level soil (health) education in Greece and the connections between soil (health) and SDGs that include *clean water and sanitation, climate action, life on land*, and *life below water* are wished to be strengthened within the formal curriculum. The educational focus often remains narrow on soil as a resource for economic activities rather than recognizing its role as a living system crucial for sustainability and ecosystem balance. This asks for adopting a balance of mechanistic and ecological paradigms to guide soil (health) education.

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To address these gaps, there is a need to emphasize on the value of soil (health) for addressing the most pressing challenges such as as climate change, soil pollution, and biodiversity loss and strengthen the connections to the SDGs within soil (health) related courses. Alongside, there is a need to develop educational approaches that focus on all the three aspects i.e. knowing, doing, and being in soil (health) education. There is an opportunity to leverage the current educational infrastructure, such as soil science laboratories, to implement these changes.

Vocational educational training (VET)

Vision: To prepare the future soil professionals with the knowledge and skills to sustainably manage soil (health) that align with the sustainability goals.
Needs: To integrate the connections to wider SDGs and develop approaches that focus on knowing, doing, and being in soil (health) education related courses.
Opportunities: Existing educational infrastructure, such as soil science laboratories can be used to implement some of the desired changes that include strengthening of doing-based activities.

State and wishes of soil (health) education

Purpose: At the VET level, there is a growing focus on the issues related to sustainable rural development and the control of intensive building urbanisation thus addressing the EU Mission Soil objectives, *stopping soil sealing and increase re-use of urban soils*. The focus on *preventing erosion* is also growing. The EU Mission Soil objective include *reduction of the EU global footprint on soils* and *reducing desertification* are very weakly embedded.

> While Greece has a strong agricultural tradition, the connection between traditional agricultural practices and modern soil (health) concepts is not fully integrated into educational content. Soil is often viewed from a purely agricultural or economic perspective, rather than as a critical component of ecological health that impacts biodiversity, water quality, and climate change.
> -A *VET trainer (from interviews).*

VET programs in Greece are increasingly emphasizing the importance of sustainable practices in rural areas. This includes teaching students how to manage land in ways that support long-term agricultural productivity, protect ecosystems, and enhance the livelihoods of rural communities. Soil sealing, the covering of the soil surface with impermeable materials due to urbanization, is a major concern in Greece. It reduces the land available for agriculture and other ecosystem services, such as water infiltration and carbon storage. VET curricula are increasingly addressing the need to control urban sprawl and intensive urbanization. This includes teaching future urban planners, architects, and construction professionals how to balance development with environmental sustainability. Soil erosion is another critical issue being addressed more robustly within VET programs. Erosion leads to the loss of fertile topsoil, reduced agricultural productivity, and increased pollution in waterways. VET programs now often

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include practical training on techniques to prevent erosion, such as contour plowing, planting cover crops, and implementing agroforestry practices.
In recent decades, there is a gradual shift towards organic and sustainable agriculture that has caused VET education to increase focus on the SDGs of *zero hunger* and *responsible consumption and production*. However, the VET level soil (health) education in Greece also should to include the SDGs of *clean water and sanitation*, *climate action*, *life on Land* and life *below water* (Barbayiannis et al., 2011).
In terms of human development, the purpose of soil (health) education is predominantly on *doing* as the VET education in Greece places emphasis on skill development, especially in the fields of subjects that include agricultural sciences (AUA, 2024). Then purpose of *knowing* is also strongly embedded via educational activities that include lectures and practical courses (UOP, 2024). The purpose of *being* is ...weakly Embedded. Being based activities are less represented as they include interpersonal and socio-emotional aspects, such as e.g. contemplation, drawings, music, etc.. In this perspective, they can only play a less significant role in soil (health) education when it comes to the academic level. Desk research indicated the need to integrate the three aspects of the purpose—*knowing, doing* and *being* in the tertiary level soil (health) education to align with the current challenges concerning sustainability (AUTH, 2024).

Collaboration: Soil (health) education at the VET level on Greece primarily involves *narrow* and *narrow-broad* collaborations and usually involves collaborators from the same sector or industry to disseminate practical and technological knowledge (Srivastava et al., 2017; Schismenos et al., 2022). *Broad* collaborations are rare which may be attributed to the fact that tertiary level focusses on specialized and specific scientific knowledge and applications around soil (health) education. This encourages collaboration between scientists and stakeholders single discipline (Efthimiou, 2020). The desk research indicated the need to broaden the vision of soil (health) education by transcending disciplinary boundaries and regional issues. This approach calls for collaboration across multiple disciplines and sectors, involving academics, industry professionals, company executives, NGO leaders, and others, extending beyond geographical and national borders.

Space: The predominant learning space for soil (health) education is *indoors*, and occurs in the classrooms mainly used to facilitate theoretical knowledge acquisition, and laboratories for learning by doing. *Outdoor* educational components are very weak. No insights into the wishes for this aspect could be gained.

Process: There is predominance of *instructive* processes in VET level soil (health) education with a focus on the transfer of predetermined knowledge, skills, procedures, etc. to support learning in a predetermined direction following two main axes: theoretical and practical. The *emancipatory* process is weakly embedded. No insights into the wishes for this aspect could be gained.

Activities: At the VET level, soil (health) education combines *knowing*-and *doing-based* activities. *Being-based* activities are very weakly embedded in soil (health) education likely due to the perception that interpersonal and socio-emotional aspects—such as

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contemplation, drawing, music, and play—are less significant in soil (health) education. However, there seems to be a recognition to integrate *being-based* activities alongside *knowing*-and *doing-based* activities to encourage awareness regarding soil (health) and sustainability AUTH (2024).

Paradigm: In VET level soil (health) education, *mechanistic* paradigm dominate. *Ecological paradigm* is weakly embedded. Desk research suggests to integrate *mechanistic* and e*cological paradigms* for an ideal soil (health) education.

Gaps, challenges & opportunities

> Government policies and educational reforms in Greece do not prioritize soil health as a key topic. Educational reforms often focus on broader competencies, digital skills, and preparing students for a globalized economy, which sideline specific environmental topics like soil (health).
> *-A researcher (from focus group).*

Currently there is an insufficient integration of SDGs in tertiary level soil (health) education in Greece and the connections between soil (health) and SDGs that include *clean water and sanitation, climate action, life on land*, and *life below water* are wished to be strengthened within the formal curriculum. The educational focus often remains narrow on soil as a resource for economic activities rather than recognizing its role as a living system crucial for sustainability and ecosystem balance. This asks for adopting a balance of mechanistic and ecological paradigms to guide soil (health) education.

To address these gaps, there is a need to emphasize on the value of soil (health) for addressing the most pressing challenges such as climate change, soil pollution, and biodiversity loss and strengthen the connections to the SDGs within soil (health) related courses. Alongside, there is a need to develop educational approaches that focus on all the three aspects i.e. knowing, doing, and being in soil (health) education. There is an opportunity to leverage the current educational infrastructure, such as soil science laboratories, to implement these changes.

General public

Vision: To create educational offers on soil (health) for general public.
Needs: To encourage and facilitate creation of soil (health) for general public by policy, financial and institutional supports and collaborations across various sectors.
Opportunities: Focusing on the eight priority SDGs recognized by Greece, including zero hunger and responsible consumption and production—both directly linked to soil (health)—presents an opportunity to create and expand educational offerings on soil (health) education for the general public.

State and wishes of soil (health) education

Purpose: Initiatives and programs to raise general public awareness about soil (health) are nearly non-existent. There are some initiatives from where soil (health) component although weakly, is inclusive, these efforts mainly focus on the EU's Common Agricultural Policy and agriculture in general. Most of these activities are offered by private

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organisations, such as the Panhellenic Congresses on Greek Agriculture and EU-funded information campaigns. There is a significant lack of government, NGO, or community-led programs dedicated specifically to soil (health) awareness.
Greece has identified and endorsed eight national priorities for SDG action; however, there are no educational initiatives aimed at raising awareness or presenting soil (health) education to the general public within the context of these SDGs.
For lack of initiatives on soil (health) education, available for the general public no insights into the state, and wishes for the purpose in terms of human development (health) could be gained.

Collaboration: The collaboration in soil (health) education for general public is often characterized by narrow collaboration , with collaborations primarily confined to specific sectors or disciplines. For example, university soil science departments may work with local farmers to share knowledge on soil management, or agricultural schools might organize field trips to farms for hands-on learning. Although these interactions are valuable, they often lack broader scope and diversity of perspectives, hence broad forms of collaboration are missing.

Space: For lack of information, no insights into the state, and wishes for space could be gained.

Process: For lack of information, no insights into the state, and wishes for process could be gained.

Activities: For lack of information, no insights into the state, and wishes for activities could be gained.

Paradigm: For lack of information, no insights into the state, and wishes for paradigm could be gained.

Gaps, challenges & opportunities

There is a need to develop soil (health) educational programs for the general public that extend beyond agriculture. To encourage and facilitate the creation of soil (health) education offers for the general public, there is a need for policy, financial, and institutional support. This includes developing policies that prioritize soil (health) education, securing funding to support educational initiatives, and fostering collaborations across various sectors such as agriculture, environment, education, and public health. With Greece recognizing eight priority SDGs, including the goals of *zero hunger* and *responsible consumption and production*, which are directly linked to soil (health), there is a significant opportunity to create and expand such educational offerings.

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A.4. Hungary

Soil (health) education across various educational levels in Hungary integrates Mission Soil objectives, such as *preventing erosion, reducing soil pollution, and enhancing soil restoration*. Additionally, there is an indirect yet notable alignment with several SDGs, including *clean water and sanitation*, *responsible consumption and production,* and *climate action*. However, explicit connections to these goals are often not clearly stated in the curriculum. In primary education, the focus is on introducing basic soil (health) concepts. Secondary education broadens this scope to include ecosystem interdependencies and sustainable development themes, encouraging students to explore complex questions about Earth's habitability. Tertiary and VET education places a strong emphasis on specialization and practical applications related to soil (health). However, broader societal challenges, such as socioeconomic inequalities, are not integrated into soil (health) educational offerings nor considered crucial for professional skills development. When considering collaborations, they expand from primarily *narrow engagements* in primary education to occasional involvement of external experts in secondary schools. In vocational education and training (VET), collaborations further extend to include industries and international exchanges.

> It (soil) should be seen as a living medium, not as a holding medium into which the seed and all other artificial material is simply inserted.
> *-A civil society representative (from focus group).*

The wishes for soil (health) education in Hungary are about aligning educational efforts with Sustainable Development Goals (SDGs) and creating personal experiences (*being*) related to soil (health) at various educational levels. It is considered especially important for the primary levels to facilitate children emotional and practical connection to soil from an early age. Expanding collaborations is another key aspiration, and depending on the educational level, the desire is to involve parents, NGOs, farmers, and experts from the public sector. Create more opportunities for hands-on learning (*doing*) and maximizing *outdoor* components are also considered important for soil (health) education. Promoting an *ecological paradigm* throughout all levels of education is crucial. This includes integrating ecological perspectives into teaching and learning methods to ensure a comprehensive understanding of sustainable soil management.

Primary education

Vision: To integrate a broader ecological perspective to soil (health) within primary education and show its connections to Mission Soil objectives and SDGs.
Needs: To revise the national curriculum to create a stronger focus on environmental and soil (health) topics and enable teachers to implement creative teaching approaches.
Opportunities: The soil (health) related initiatives that employed the envisioned approaches of outdoor, emancipatory, doing based teaching already exist in the past. (Re-)establishing broad access to these approaches through financial and governmental support offers opportunity to implement the wished forms of soil (health) education.

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State and wishes of soil (health) education

Purpose: At the primary level, soil (health) related teaching generally focuses on certain Mission Soil objectives that include *preventing erosion, reducing soil pollution and enhancing restoration,* and *stopping soil sealing and increase re-use of urban soils*. For instance, an elective modul of the subject 'Technics and Design' taught in the 6th grade of primary school places a special emphasis on soil (health), and specifically raises the question to the students, ''Can we change the quality of the soil?'' considering the importance of irrigation and soil nutrients (Fodorné, 2020). Another examples include teaching about soil contamination using a 3D model (Mozaik Education, 2023) and teaching about nutrient cycling in soil with example of composting (Halbritter, et al. 2020). The education related to soil (health) does not explicitly mentions any of the SDG, however, the connections with several SDGs such as *clean water and sanitation, responsible consumption and production* (Fodorné Magyar et al., 2020) and *climate action* (Fodorné Magyar & Halbritter, 2022) are indirectly present.. The wish is to emphasize the links to various themes and goals of soil (health) captured in Mission Soil objectives and SDGs but still without explicitly mentioning EU Mission Soil objectives or SDGs.

In terms of human development, the purpose of soil (health) education is predominantly *Knowing* as teaching prediminantly relies on reading textbooks and lectures. Lectures are often supplemented with videos and 3D models (Mozaik Education, 2023) and some hands-on learning (*doing)* primarily in school gardens. For instance, students learn about the process of composting (e.g. role of worms in composting, effect of compaction and different types of residues like garden waste, food residues, animal waste). Then they practice composting using the garden waste. By doing so they learn more about how the presence of certain components (e.g. food and animal waste) can create foul smell and attract rodents, as well as about the organisms in soil and their nutritional needs (Halbritter et al, 2020). Facilitating personal experiences (*being)* is not embedded in primary education. The wish is to embed *being*, and to strengthen *doing*.

Collaboration: Soil (health) education in primary schools in Hungary is *narrow* and primarily involves students and teachers. Examples of collaborators beyond teachers and students, such as farm-based education and forest schools, have existed in the past. Due to a lack of time and financial resources, these initiatives are much less accessible in mainstream primary education. The wish is to broaden the collaboration and include parents, NGOs, farmers and experts in public sector.

Space: Soil (health) education in primary schools in Hungary is almost always conducted *indoors*, in classrooms or laboratories with very few *outdoor* activities. Interviews provided an insight that although not mainstream, in certain schools (e.g. in the approximately 40 Waldorf schools offering Steiner education rooted in anthroposophy (Magyar Waldorf Szövetség, 2023)) outdoor education on soil (health) is dominant and students learn in school gardens and fields. The wish is to create and maximise the opportunities of *outdoor* components in soil (health) education.

> if there's potted flower, they (teacher) will take it and show you what the soil is like inside
> *-An environmental educator (from interviews).*

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Process: Soil (health) education at primary level in Hungary is predominantly facilitated via *instructive* process and relies on transfer of pre-defined knowledge through lectures, books, textbooks and films. *Emancipatory processe*s are weakly embedded. For instance, an interview participant presented an example of a Waldorf school , where students learn through observation and conversation. Teachers, for example, explain the differences between soil nutrient cycles in a forest and a cropland while students observe. The wish is to embed and strengthen *emancipatory* processes.

Activities: In the primary education, soil (health) education is facilitated predominantly by *Knowing-based* activities (e.g. gaining knowledge from textbooks) with some minor components of *doing-based* activities. Examples of *doing-based* activities include students performing educational activities in school gardens for instance in composting or performing experiments related to soils (e.g. detection of pollutants entering soil (Fodorné Magyar, et al. 2020). *Being-based* activities are missing. Wish is to embed *doing-* and *being-based activities*.

Paradigm: A review of soil education resources for primary schools indicates an almost exclusive *mechanistic* paradigm, with specific focus on soil structure, components, their properties and soil conservation, which are addressed separately (Horváthné Kunstár & Kissné Gera, 2023). The e*cological* paradigm is absent, and the wish is to embed it.

Gaps, challenges & opportunities

The national curriculum in the primary schools in Hungary have a weak focus on environmental topics, which are absent in the first two grades, with limited coverage in subsequent years. This restricts early exposure to ecological principles and sustainability concepts among young students. Soil (health) aspects are largely overlooked in the curriculum. There is a wish to presents the importance of soil (health) for EU mission and SDGs, and facilitate this education while incorporating *emancipatory* processes that incorporated *knowing-, doing-* and *being-based* activities in predominantly outdoor settings.Achieving these wishes face certain challenges. In addition to the content gaps on soil (health), teachers face constraints imposed by centrally prescribed textbooks especially in public schools which curb their flexibility and creativity in integrating soil (health) related content across various subjects. Furthermore, due to lack of time, resources and administrative support from their superiors (e.g. school principals), the teachers have limited scope of fitting the soil (health) topics within teaching schedules. Lack of funding and government support has resulted into limited access to several environmental and soil (health) related education initiatives, such as farm-based education, forest schools, and eco-schools. This funding shortfall has particularly affected NGOs working on environmental education. Such successful practices like forest schools, winter camps, and school gardens need to be revived by allocating resources and revising the current national curriculum to integrate environmental and soil (health) related topics. While the teachers need more flexibility to be able to introduce soil (health) within their teaching, there is also need for changing the attitude towards education which currently is focussed on *knowing*.

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Secondary education

Vision: To integrate soil (health) and their connections with SDGs more deeply into the curriculum and to align with the broader sustainability goals.
Needs: To revise the national curriculum to implement the core components of knowing, doing, and being and facilitate more outdoor activities, collaborative projects, and emancipatory learning processes.
Opportunities: Alternative schools serve as examples of how mainstream education can align with the wished changes in soil (health) education direction.

State and wishes of soil (health) education

Purpose: In secondary education in Hungary, there is a greater emphasis on understanding the interdependencies within ecosystems, including soil, compared to the primary level. The curriculum and textbooks for secondary education briefly address topics such as soil improvement and soil protection as part of sustainable development which extends to address the importance of soil (health). The courses tackle broad questions like, "Will the Earth remain habitable?" (Nagy & F. Kusztor, 2020). Consequently, most of the Mission Soil objectives—such as *reducing desertification, conserving soil organic carbon stocks, reducing soil pollution and enhancing restoration, preventing erosion, and improving soil structure to enhance soil biodiversity*—are covered. The concept of human footprints is discussed, though rarely in relation to soil (*reducing the EU global footprint on soils*), and the *improvement of soil literacy in society* is also weakly embedded (F. Kusztor et al., 2021).

The SDGs related to soil (health) are not explicitly mentioned but are implicit in sustainability-related topics. The SDGs implicitly embedded include *zero hunger, good health and well-being, clean water and sanitation, affordable and clean energy, responsible consumption and production, climate action, life below water, life on land*, and *industry, innovation and infrastructure, and sustainable cities and communities* (F. Kusztor et al., 2021). However, the social and human aspects are practically missing. There are no mentions of goals like *quality education, reduced inequalities, decent work and economic growth. T*he wish is to create a greater focus *on improving soil literacy in society, reducing soil pollution, enhancing restoration*, and *preventing erosion,* while also emphasizing *quality education and life on land*.

In terms of human development, the purpose of soil (health) education at the secondary level is *knowing* and *doing*. The courses combine lecture and textbook based knowledge acquisition, supplemented with videos and 3D models which enriches the teacher's explanation. In addition, students conduct group and project activities, experiments and observations, hike on educational trails, and model liveable cities and settlements. For instance, students perform experiments and make observations on what happens to turf bricks (vegetation on soil) when water is poured over them and how a covering of leaf residuals affect the process. This hands-on experiment teaches students about soil erosion and the importance of vegetation in soil conservation, and fosters critical thinking and practical understanding (Jónás et al., 2023). There are further examples of

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encouraging critical thinking for instance by engaging students in planning conferences on crucial challenges in near future, or facilitating a discussion following thought provoking films (Jónás et al., 2023). Such activities also facilitate exploration of student's personal relationship with soil (health) and therefore, the aspect of *being* is indirectly embedded. The wish is to emphasize the *doing* aspect of education and to let students' first-hand experiences, through experiential forms of learning, influence their *being and* a deeper emotional connection with soil.

Collaboration: Soil (health) education in secondary schools in Hungary is predominantly *narrow* and *narrow-broad* and usually includes stakeholders from the same and related professions and disciplines, such as geography, biology, and technology teachers. In some secondary schools, external specialists participate in theme weeks (e.g., Sustainability Theme Week), working directly with students on related projects. An example is the theme week "Epocha/Project - Getting to Know a Microregion" (G AKG, 2020), where students explore the life of a small region or microregion through an interdisciplinary approach, simultaneously examining ethnographic, historical, geographical, economic, sociological, municipal, and cultural aspects. The wish is to make the collaborations *broad.*

Space: Soil (health) education in secondary schools in Hungary is predominantly conducted *indoors*, in classrooms or laboratories with very minor components of *outdoor* activities such as targeted trips and camps focused on environmental protection and nature observations. Examples of *outdoor* education activities include Project Week: Getting to Know a Microregion, which entails three days of fieldwork in chosen locations (AKG, 2020). Additionally, students are encouraged to visit sodic soils and measure the pH of the soil solution using litmus paper (Czippán. et al., 2022). The wish is to create and maximise the opportunities of *outdoor* components in soil (health) education.

Process: Soil (health) education in secondary schools facilitated through a combination of *instructive* and *emancipatory* processes. The *instructive processes* mainly include textbooks supplemented by digital contents. This is accompanied with *emancipatory* processes based on peer to peer learning (e.g. group activities) and problem solving. An example of an *emancipatory* approach is the 1Project on Sustainable Consumption (AKG, 2020)). In this project, students explore the topic of sustainable consumption using a multifaceted approach. They conduct interviews (e.g. family members, teachers, undergraduate students, etc). Students also create videos and write original articles addressing different aspects of the topic, they are challenged to compose a problem summary synthesizing their insights. The wish is to strengthen *emancipatory* processes.

Activities: At the secondary school level, soil (health) education integrates both *knowing*- and *doing-based* activities. *Doing-based* activities include laboratory experiments, planting exercises, and communication exercises. Students also engage in project work, e.g. creating school gardens, and constructing temporary sites and models. For instance, at the Alternative Secondary School of Economics, students collaborate in groups to conduct research, describe, and propose solutions related to a micro-region (AKG, 2020). This interdisciplinary approach incorporates soil (health)-related questions, fostering a

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hands-on approach to learning about environmental sustainability and local ecosystems (AKG, 2020). *Being-based* activities are weakly embedded. A few alternative schools try to incorporate *being-based* activities. The wish is emphasise *doing-based* acitivities as they are considered feasible.

Paradigm: Soil (health) education at secondary school level embraces in some cases an *ecological paradigm, however the mechanistic paradigm is the dominant approach*. The curriculum focusses acknowledge and address the complexity in nature (and soil) and focuses on the relationship between soil (health), environmental factors and human activities. For example, The textbook Czippán, K. et al. (2021) presents the concept of sustainability, emphasizing the need for harmony among nature, economy, and society to achieve it, highlighting the risks of disproportionate resource use, environmental pollution, and social inequalities as hindrances to both economic development and the preservation of Earth's existence, using the analogy of a three-legged table for stability. Interviews suggested that soil (health) is taught within a relatively strong *mechanistic paradigm.* Wish is to further strengthen the *ecological paradigm*.

> The big goal is to get to know the processes and connections well, not just touching on the topic.
> -A s*econdary school teacher (from*

Gaps, challenges & opportunities

There is insufficient integration and emphasis of soil (health) within the educational curriculum, which further impedes presenting soil (health) in its broader context and related issues. Social awareness about the role of soil in sustainable development is also lacking, and it is therefore important to embed its importance in students' consciousness from an early age. Current educational design predominantly focusses on knowledge transfer and hand-on activities, with little encouragement of personal engagement (*being*). To narrow the gap with the envisioning of increased focus on *being-based* activities and more *emancipatory* approach to soil (health) education, there is need to create enthusiasm and change in attitude towards education. This will allow teachers to connect soil (health) education with the SDGs which are already embedded in the curriculum as well as explore opportunities of cost-efficient *outdoor* activities which can be as simple as taking students outside school building. Alongside, there is a need to broaden the collaborations and expand it beyond teachers, parents and researchers to include social science experts, artists, legislators and policy makers.

> I feel that they get very little information about the soil at school and in high school as well.
> *-A public administrator (from interviews).*

Resource scarcity and time constraints further challenge the implementation of innovative teaching methods, while the traditional classroom-based framework remains a barrier to integrating *outdoor* and experiential learning opportunities effectively. However, opportunities exist to expand learning approaches, collaborate more broadly with stakeholders like researchers and policymakers, and enhance *emancipatory* education processes, as is being demonstrated in alternative school settings.

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Tertiary education

Vision: To broaden the purpose of soil (health) education to encompass the wider connections of societal and economic developmental needs, and to foster a personal relationship with soil (health).
Needs: To include more interdisciplinary and experiential learning opportunities that connect soil (health) with broader societal issues, such as socioeconomic and gender inequalities, and focus on integral skills within overall professional development in the agricultural sector.
Opportunities: Leveraging existing collaborations and emancipatory approaches and expand it to incorporate the skills necessary for connecting soil (health) with sustainable developmental needs.

State and wishes of soil (health) education

Purpose: Tertiary education in Hungary is highly specialised, and agricultural science courses address the soil (health) relate topics comprehensively. These cover most of the Mission Soil objectives, with emphasis on *reducing desertification, conserving soil organic carbon stocks, stopping soil sealing and increase re-use of urban soils, reducing soil pollution and enhance restoration, preventing erosion, improving soil structure to enhance soil biodiversity, reducing the EU global footprint on soils.* However, *increasing soil literacy in society* is not addressed. The tertiary level education aims at professional development, and overlooks human and social issues. Consequently, SDGs such as *no poverty, zero hunger, gender equality,* etc. are not addressed in relation to soil (health) education. However, SDGs directly relatable to agriculture such as *clean water and sanitation*, *affordable and clean energy*, and *climate action* are present (MATE, 2023a). The wish is to give more visibility and publicity to the topic of soil not only in the education, but in the wider society (*improving soil literacy in society*) and *preventing erosion* given the increasing rate of soil degradation in Hungary. The following SDGs are also wished to be presented in relation to soil (health): *quality education, clean water and sanitation, industry, innovation and infrastructure, sustainable cities and communities, responsible consumption and production, life on land, partnerships for the goals*
In terms of human development, the purpose of soil (health) education is acquiring knowledge (*knowing*) and skill development (*doing*), which are clearly differentiated in teaching and assessments at tertiary level. The skill development (doing) aspect is aimed for overall professional education which includes learning applied techniques such as laboratory work as well as internships at organisations to develop real world experience of applying knowledge and skills, as well as learning to collaborate, communicate, innovate and solve problems (MATE, 2023c). While the emphasis on *being* is weakly embedded, it indirectly emerges from education that focuses on interpersonal relationships and personality development. The wish is to place the focus on *knowing*, given that the new generation of teachers appears to have a less deep knowledge of soil (health), while also strengthening the aspects of *doing* and *being*.

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Collaboration: Tertiary level soil (health) education was found to have predominantly a *narrow-broad and* to some extent *broad focus.* For instance, interns and students collaborate with professionals such as engineers, machine operators, farmers, and institutional employees. Additionally, through the Erasmus+ project, students can work with international peers, employers, specialists, and researchers on specific topics. There are also interdisciplinary conferences e.g. National Scientific Student Research Conference, at the Agricultural Science Section in which soil (health) related issued are included (OTDK, 2023). *Narrow* collaborations are not typical. The wish is to continue with the current forms of collaborations.

Space: Soil (health) education at tertiary level is offered both *indoors* and *outdoors*. *Indoor* education occurs mainly during the seminars and laboratory experiments. In addition, students have several options for *outdoor* activities, that include several choices of external locations and practical places, for instance during internships of at least six weeks (MATE, 2023b). The wish is to strengthen *outdoor* components.

Process: At tertiary level soil (health) education, a combination of *instructive* or *emancipatory* processes are used. *Instructive process* includes lectures, notes, book readings, tests, and written and oral examinations. These are complimented by *emancipatory processes* such as seminar theses, joint project work, professional practices, and participation in the OTDK (National Scientific Student Research Conference, see e.g. OTDK, 2023). The wish is to strengthen *emancipatory* processes wherever it is feasible.

Activities: At the tertiary level of education in Hungary, soil (health) education combines *knowing-based* and *doing-based* activities to provide students with a comprehensive learning experience. Theoretical background is delivered through lectures, study of published literature, seminar reports, and written and oral exams. In addition, students acquire applied professional skills through active fieldwork and internships. Review of course materials suggests that *being-based* activities are not embedded, however interviews provided insights that *being-based activities* are also embedded, though not explicitly mentioned. The wish is to continue with the current state of *knowing-, doing-* and *being-based activities*.

Paradigm: Review of course suggests predominance of *Ecological* paradigm, while the insights gained from the interviews indicate that both *mechanistic* and *ecological* paradigms are strongly present at tertiary level soil (health) education in Hungary. The wish is to shift towards a predominance of *ecological* paradigm.

> When we start talking about soil (health), it has a metaphorical message: wow, it is truly a living system that can have problems, can feel bad, and if it feels bad, it performs poorly. *-A university lecturer (from interviews).*

Gaps, challenges & opportunities

Tertiary level education in Hungary is highly specialized and primarily focused on professional development. As a result, even though soil (health) topics are covered comprehensively, they are almost always taught within the context of agriculture. This specificity often leads to a lack

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of an interdisciplinary approach that could provide a more systemic understanding of soil (health) and societal challenges such as *no poverty, quality education*, and *reduced inequalities*—are not considered important skills in relation to soil (health) education. Consequently, these connections are missing from the curriculum. The education system also lacks *being-based* activities and experiential or artistic treatments of agricultural and soil (health)-related topics. Addressing these gaps requires a shift in educational paradigms, which is inherently challenging. Furthermore, there is a general neglect of soil (health) among the broader society, and there is a pressing need to create a greater focus on *improving soil literacy in society*. Including policymakers and administration into the existing collaborations that exist between educational institutions and economic sectors can bridge the gap between education and practical applications in the real world. Leveraging existing specialized university programs can help expand their reach and impact.

Vocational educational training (VET)

Vision: To integrate interdisciplinary perspectives and foster a *knowing, doing* and *being* based education that connects soil (health) with broader societal and economic development goals.
Needs: To strengthen collaborations across disciplines, including policymakers and diverse stakeholders, to enrich educational perspectives and address multifaceted challenges.
Opportunities: The existing collaborations such as during theme weeks present examples that can be expanded.

State and wishes of soil (health) education

Purpose: The vocational schools specializing in agriculture, horticulture, forestry, and environmental protection include professional subjects that cover soil, soil (health), and soil protection topics. These courses comprehensively focus on the structure, analysis, and protection of the soil and address most of the Mission Soil objectives. For example, the subject, Environmental Protection Technologies (Veszprémi Szaképzési Centrum Ipari Technikum, 2023) adresses:*reducing desertification, conserving soil organic carbon stocks, stopping soil sealing and increase re-use of urban soils, reducing soil pollution and enhance restoration, preventing erosion, improving soil structure to enhance soil biodiversity*. The concept of human footprints is introduced but there is no mention of *reducing EU footprints on soil* or *improving soil literacy in society*. The courses however, do not explicitly mention SDGs or bring attention to what roles soil (health) play in the context of broader social development goals. However, subjects that focus on sustainability (e.g. Veszprémi Szaképzési Centrum Ipari Technikum, 2023) include topics on environment and health, ecological footprints (Tüskés, 2015), etc. and implicitly address certain SDGs like *good health and well-being, clean water and sanitation, affordable and clean energy* (Kerberné Varga, 2016) *sustainable cities and communities, responsible consumption and production, climate action, life below water* and *life on land*. Other SDGs that include *no poverty, quality education, gender equality* etc. are absent. The wish is to create bigger focus on *improving soil literacy in society*.

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In terms of human development, there is a focus on *doing* and *knowing* which aligns with the primary goal of VET education to create practitioners with adequate theoretical understanding as well as skill-set for real world applications. The hand-on practical learning takes prominence and includes activities such as soil sampling and detailed physicochemical analysis (Veszprémi Szaképzési Centrum Ipari Technikum, 2023). In addition to these structured education, there are activities such as participating in climate change focussed negotiations and conference (e.g. Petrik, 2022) which facilitate students to think about and address the most pressing challenges such as climate change. While the purpose of *being* is not explicitly evident, it very likely emerges during the process of developing in-depth understanding and hands-on learning with soil. Wish is to strengthen *doing* as central focus for VET education related to soil (health).

Collaboration: Collaborations in soil (health) education in VET in Hungary is predominantly *narrow* and is mostly limited to the students and teachers with occasional engagement of experts from related fields (e.g. horticulture expert during practical learning in horticulture or forestry farm employees during examination of forest soil). However, during 'theme weeks' focussed on different aspects of environmental protection, VET schools collaborate with experts from other disciplines in the form of invited lectures and workshops. For example during the field event for students of the Kisalföld ASZC Roth Gyula Forestry Technician, Vocational Training School And College , an expert delivered a series of lectures on the formation of our Earth, changes in environmental elements, including soil, and more complex ecosystems (Rothszki, 2023) *Narrow-broad* and *broad* collaborations are weakly embedded. No clear wish for collaborations emerged.

Space: Most soil (health) education related VET programs take place both *indoors* and *outdoors*. Due to focus of VET programs on learning practicals, there are frequently outdoor activities (e.g. agricultural land or a factory). For example, in the course Natural science studies' (Veszprémi Szaképzési Centrum Ipari Technikum, 2023), at least 40% of the hours are recommended to be spent on *outdoor* and on-site practical learning. Wish it to strengthen the *outdoor* component.

Process: In soil (health) education related VET programs, both *instructive* and *emancipatory* processes are present. The VET courses related to soil (health) education often require group work that include knowledge sharing, joint activities on projects and creation of solutions to a problem at hand. For example, during a project competition "Love the Earth!", students were assigned the task of creating a comic on topics such as environmental protection and sustainable development (Fáyntos, 2024). The wish is to strengthen *emancipatory processes*.

> They (a company) announced a tender to open a community garden in Kőbánya, and they wanted students to design it.
> *-A student in gardening and agriculture (from interviews).*

Activities: The VET education in Hungary is primarily facilitated by a combination of *knowing-based* activities and *doing-based* activities. *Doing-based* activities include learning by performing experiments, and applying practical skills such as planting, as well as developing their communication skills. An example of a practical task is the estimation of ecological footprint using an online tool (www.kothalo.hu/labnyom!) and then the

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comparison of the findings with the ecological footprints estimated for other countries (Kerberné Varga, 2016). Another example is the extreme soil science camp (MAGRO, 2022) during which students gained extensive theoretical knowledge on soil alongside engaging in activities such as flying drone, creating 3D relief models, and learning digital soil mapping theory. Practical sessions included soil profile preparation and mapping, as well as demonstrations of various machines. Additionally, the camp featured games focusing on land use, ethnography, and ecology. Students also explored alternative land use methods like agroforestry and grazing, which are beneficial for soil (health) and sustainability. *Being-based* activities are not embedded in VET courses. No clear insights into the wishes on this aspect were gained, however the interviews indicated desire to place greater emphasis on *doing-based* activities.

Paradigm: Soil (health) education in VET programs is predominantly approached from a *mechanistic* paradigm where focus is on creating a deeper understanding on specific properties and processes related to soil (health). The *ecological* paradigm is subtly present and while it may appear to be missing if individual chapters/modules are examined, it becomes evident when the entire course is considered. For instance, the textbook (Kerberné Varga, 2016) for 10th grade mentions, ''Animate and inanimate in global (covering the entire Earth) processes cannot be sharply separated''. No insights on this aspect could be gained.

Gaps, challenges & opportunities

VET courses typically prioritize directly applicable professional skills in related fields such as agriculture, horticulture, and forestry, often leading to a disconnect between soil (health) and broader socioeconomic development goals. This gap should be narrowed by establishing connections between soil (health) and broader societal and economic well-being. Encouraging collaborations that involve policymakers, multiple disciplines, and stakeholders can facilitate the incorporation of diverse perspectives and address challenges from various angles. However, the current established and rigid educational framework poses obstacles to such changes. Moreover, there is limited emphasis on fostering personal relationships (*being*), which should be integrated into the curriculum. This inclusion can broaden the educational perspective and contribute to linking soil (health) with broader SDGs.
On a positive note, the educational design aligns closely with envisioned paradigms, purposes, processes, and learning spaces. Examples such as theme weeks demonstrate collaborations with external experts and stakeholders, which can be further leveraged. Additionally, existing public awareness campaigns can be utilized to enhance students' and society's integrated understanding, promoting sustainable practices and societal well-being.

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General public

Vision: To enhance soil (health) awareness as a key component of broader environmental and sustainability education, enabling people to appreciate the value of healthy soil through knowledge, action, and personal connection.
Needs: To provide financial support and encourage broader collaborations when developing and implementing the programs for soil (health) education catering to diverse target groups in general public.
Opportunities: Citizen science initiatives provide a concrete opportunity to engage the general public in soil (health) education in a participatory manner.

State and wishes of soil (health) education

Purpose: Most educational resources concerning soil (health) targeted at the general public are geared towards farmers. Additionally, other educational materials aimed at the general public focus predominantly on topics like composting and mulching, tailored mainly for urban gardeners and hobbyists, with an emphasis on promoting the reuse of urban soils. These materials address most of the Mission Soil objectives that include *reducing desertification, conserving soil organic carbon stock, reducing soil pollution and enhance restoration, preventing erosion, improving soil structure to enhance soil biodiversity,* as well as *improving soil literacy in society*. The educational materials on soil (health) for general public lack explicit connections with the SDGs, however come of the SDGs are implicit, which include *good health and well-being* (Magyar Permakultúra Egyesület, 2024), *sustainable cities and communities,* responsible consumption and production, *climate action* (HUMUSZ Szövetség (2020), life below water [ME, 2018),and *life on land* (Körforgásban (2023). No insights on the specific wishes on these aspects were gained.

In terms of human development, the purpose is on *doing*, with learners developing skills related to soil (health) such as composting or practicing regenerative farming through several training programs for instance provided by NGOs like the Permaculture Association and the Soil REgeneration Farmers Association. Additionally, there is a focus on expanding knowledge, as demonstrated by resources like HUMUSZ Szövetség (2014) and HUMUSZ Szövetség (2020). *Being* focussed soil (health) educational program is missing. The wish is to have an integration of *knowing, doing and being* when it comes to the purpose of soil (health) education for general public.

Collaboration: The soil (health) related education for the general public is predominantly offered through *narrow* collaborations with occasional engagement of multiple stakeholders leading to *narrow-broad* collaborations. An example of narrow-broad collaboration is the annual Soil Renewal Farmers' Conference, which brings together farmers, producers, university professors, agricultural machinery manufacturers and representatives of ministries (Agrofórum Online (2024). *Broad* collaborations are rare. An example of *broad* collaboration is the nationwide citizen science program "Soil your Undies," where participants perform a simple experiment by burying a pair of cotton underwear in soil to assess the decomposition rate, which serves as an indicator of soil

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life activity and, indirectly, soil (health) (Árvai et al, 2023). The wish is to keep expanding the collaborations and make them *broad*.

Space: Educational resources for general public are offered both *indoor* and *outdoors.* The *indoor* oriented resources include educational booklets, videos, podcasts such as Ökológiai Intézet (2014) and Földes (2016) which provide foundational knowledge. However, these along with other resources primarily aim to encourage people to learn *outdoors* and include activities such as soil profile testing, permaculture training in permaculture gardens, compost festivals, and soil camps. For instance, Soil Renewal Farmers offer educational sessions, and events like the extreme soil camps provide hands-on learning experiences （Agrofórum Online (2023a)). The wish is to continue with the combination of *indoor* and *outdoor* learning.

Process: Our desk research indicated that soil (health) awareness offers for general public are facilitated through a combination of *instructive* (e.g. Best4Soil Network (2020)) and *emancipatory* processes. An example of where emancipatory process is dominant include the 'Composting Day' of the HUMUS Association (HUMUSZ Szövetség,2023) where participants practice composting. The wish is to have both—*instructive* and *emancipatory* processes.

Activities: In soil (health) awareness offers for general public, a both *knowing-based* and *doing-based* activities are used. For example, soil profile test（Axial, 2023) is primarily a *knowing-based* activity whereas practical training programs offered by the Soil Renewal Farmers Association（Agrofórum Online (2023b) employ *doing-based activities*.

Desk research suggests that *being-based* activities are not strongly integrated into available educational resources for the general public. However, insights gained from interviews indicate that the *being-based* activities are deeply ingrained in practices and decisions related to farming, and these connect to the societal norms and are important from the religious perspective when it comes to church related charities. The wish is to adopt activities that combine all three: *knowing-, doing-*, and *being-based* activities.

Paradigm: Soil (health) awareness offers for general public predominantly adopts *ecological* paradigm with components of *mechanistic paradigms*. For instance, Démétér Biosystems.(2024) that presents 5 principles of soil (health) for interested general public, adopts the USDA's definition of soil (health) (soil (health) means the continued ability of soil to function as a living ecosystem that supports plants, animals and people) which connects to the *ecological* paradigm. However, when soil (health) is addressed concerning specific topics (e.g. home gardening), the focus shifts to more specific aspects of soil (health) such as soil fertility for the target plants (ÖMKI, 2024). The wish is to continue with a contextually balanced *mechanistic* and *ecological* paradigms.

> This question of authenticity is very important. We don't want to sell him [farmer] a chemical or whatever, we want to give him our knowledge.
> *–A university Lecturer (from interviews).*

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Gaps, challenges & opportunities

Educational resources related to soil (health) that target general public largely focus on either agriculture (with farmers as target group) or gardening. Combined with lack of awareness on the SDGs, there's a notable gap in public awareness regarding the importance of soil (health) for sustainable development. The state of awareness on environmental issues that also include those related to soil such as unnecessary use of chemicals in farming and gardening, is poor. To address these gaps, there is a need to create programs that not only focus on soil (health) but on the broader environmental and sustainability issues, especially those that different audiences can personally relate to e.g. connections of soil (health) and water pollution. These programs would greatly benefit from collaborative efforts involving civil society organizations and engaging various stakeholders, including experts and the general public. Moreover, society is moving away from traditional practices, many of which are beneficial for conserving soil (health) and are less degrading to the soil and the environment compared to currently mainstream practices such as chemical applications to soil. It is essential to recognize the value of these positive traditional practices, which can also help integrating the *knowing, doing* and *being* as purpose of soil (health) education to the society. To address these needs, it is crucial to provide financial support.

Projects such as citizen science initiatives offer an excellent opportunity to engage the general public in learning about soil (health) in a participatory manner. These initiatives not only raise awareness about the importance of soil conservation but also empower individuals to contribute to scientific research and environmental stewardship.

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A.5. Ireland

> I would like to see all educators and local communities come together
> -An MSc (Sustainable Development) student *(from interviews)*

In Ireland, the soil (health) education across all educational levels has a predominant focus on knowledge acquisition (*knowing*) and on skill development (*doing*) at most educational levels, and the purpose of *being*, i.e. to explore and develop one's personal connection with soil (health) is very weakly embedded or absent. At the primary and secondary levels, soil (health) topics are embedded into subjects such as Geography and Science and gradually increase in complexity as students advance. At secondary education external programs incorporate soil (health) education in addition to the core curriculum which mainly emphasizes soil (health) within broader environmental challenges. At the tertiary level, the education is more specialized, with courses addressing soil management, nutrient cycling, and sustainability. Despite these offerings, there is a noticeable gap in addressing key soil challenges like soil pollution, desertification, and urban soil reuse across all levels, with *outdoor learning* and *emancipatory* learning (i.e. empowering participants to shape the direction of their learning), and *broad* collaborations being limited. There are limited offers available to the public, and the research indicated the need for creating more offers and engaging the general public.
Across educational levels, there is a consistent wish to integrate more *doing*- and *being-based* activities, that enable hands-on experiences and development of personal connections with soil (health). There is also a desire to approach soil (health) education from an *ecological paradigm* that recognizes the interconnectedness of soil (health) with broader ecological and human systems. In addition, there is a recognition of the importance of expanding collaborations with external stakeholders, such as NGOs and community groups, and integrating more *outdoor* learning opportunities. At the primary level, there is a wish to make soil (health) education more engaging and holistic, while at the tertiary level, there is a desire to broaden collaborations and enhance interdisciplinary learning. Overall, the vision for soil (health) education in Ireland is to create a more integrated, hands-on approach that emphasizes sustainability and ecological awareness.

Primary education

Vision: To expand collaborations, adopt emancipatory approaches and prioritize outdoor learning in soil (health) education, integrating knowing-, doing-, and being-based activities.
Needs: To enable teachers in implementing the envisioned educational design for soil (health) education through specialized training, allocation of required resources (outdoor spaces, educational resources designed for emancipatory learning) and reducing workload.
Opportunities: The 'wellbeing program time' in schools offers a potential opportunity to allow for outdoor learning activities related to soil (health).

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State and wishes of soil (health) education

Purpose: Soil (health) education is mainly embedded into the subjects Geography and Science, and it gradually increases in depth and complexity from infant classes to 6th class (age 12). The three subjects, Science, Geography and History, are incorporated into a curriculum area called Social, Environmental and Scientific Education in Irish primary education. Pupils in infant classes observe, sort and group the soil for instance as rocks, pebbles, and mud (Department of Education and Science, NCCA, 1999a). In 3rd and 4th class (age 9 to 10), there is a more detailed exploration, where students examine soil samples and gain understanding of how soil (health) affects plants, animals and ecosystems (Department of Education and Science, NCCA, 1999a). The curriculum at primary level , predominantly focusses on the Mission Soil objectives to *improve soil literacy in society, improve soil structure to enhance soil biodiversity,* and *preventing erosion although these themes are not explicitly identified*. The goals to *conserve soil organic carbon stocks* and *reduce soil pollution and enhance restoration* are weakly embedded, and the goals of *reducing desertification, stopping soil sealing and increasing re-use of urban soils,* and *reducing the EU global footprint on soils* are absent. However, the goal to conserve soil organic carbon stocks is emphasised in soil (health) education provided by the NGOs, especially in the context of Peat Bogs, which are significant landscapes in Ireland.

> The move towards Astroturf pitches - they're an environmental disaster. They've removed all the life in the soil and kids are going home with microplastics hanging off their clothes. If we can intercept a school before they've done it, we recommend that they stay with sand pitches.
> *- An NGO educator (from interviews).*

Among the SDGs, soil (health) education predominantly integrates *quality education*—evident in practices that promote critical thinking about soil (health) and its wider significance for flora and fauna (Department of Education and Science, NCCA, 1999b)—as well as *good health and well-being*, through lessons on physical conditions including soil factors that affect food quality, establishing the connection between nutritious food such as fruit and vegetables and farming activity and healthy soils (Department of Education and Science, NCCA, 1999a), and *life on land*. The interviews indicated that these SDGs along with the goal of *sustainable cities and communities* are further being embedded in NGO led education and primary teacher training colleges (e.g. Courses from Irish school sustainability network: 5 Minutes of Sustainability, Climate and Nature Summit (ISSN, 2024). The SDGs of *zero hunger* and *decent work and economic growth* are weakly embedded in the curriculum and are specifically focussed in the context of farming (Department of Education and Science, NCCA, 1999b). *Partnerships for the goals* are also weakly embedded as the curriculum for Geography and Science where soil (health) educational topics are taught encourages collaborations between parents, teachers, local libraries and authorities, and businesses. The SDGs that include *reducing inequalities, climate action*, *responsible consumption and production*, etc. are absent. The wish is to strengthen the focus on *zero hunger, good health and well-being* and *climate action* in primary education related to soil (health).

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In terms of human development, the purpose of soil (health) education primarily is *Knowing* and *doing.* For instance, pupils are encouraged to explore soil (health) processes, and its relationships with abiotic and biotic components. There are activities of observing, collecting, and investigating natural materials including soil, mud and sand, (Department of Education and Science, NCCA, 1999a, p.41). Although, frequency and depth of these practical activities are not clearly detailed in the literature, these are very likely strongly embedded. The purpose of *being* is weakly embedded. For instance, two strands in Geography in environmental awareness and care are 1. caring for my locality and 2. environmental awareness. These encourage the pupils to have connections with the natural world thereby possibly developing a sense of responsibility towards it. No insights on the wishes for these aspects of purpose could be gained.

Collaboration: Educational resources related to soil (health) are predominantly integrated into Social Environmental and Scientific Education (SESE) Geography and Science, where the collaborations are primarily narrow-broad, and involve professionals from the education sector e.g. teachers, school principals, and curriculum developers, while broad collaborations are absent. Narrow collaborations are weakly embedded . Recently, however, the revised primary school curriculum is being designed in consultation with stakeholders from other sectors, and focusing on diversity, ethos, language, and inclusion (NCCA, 2024a). *Broad* collaborations were found to be missing. The wish is to make the collaboration broad, specifically by engaging more NGOs, educators and community groups.

Space: Soil (health) education in primary schools in the Ireland is conducted *indoors* with components of *outdoor* education. The desk-research indicated that the curriculum for Science and Geography mentions soil (health) related activities that are conducted outdoors. For instance, activities such as digging holes, taking soil samples, and exploring soil profiles are recommended as fieldwork in schoolyards. There are also activities that include observing soil and exploring habitats that have a strong focus on outdoor environments such as gardens, farms, or forests. However, these outdoor activities are complemented by indoor work, including tasks presented in textbooks (Department of Education and Science, NCCA, 1999b; 1999d). The interviews however, presented an insight that the soil (health) education in practice predominantly occurs indoors with occasional outdoor activities. The wish is to conduct soil (health) education predominantly outdoors.

Process: Soil (health) education for primary schools in Ireland is primarily facilitated through *instructive* processes. Teachers follow guidelines on content, school and classroom planning, teaching methods, and subject-specific aims and objectives (Department of Education and Science, NCCA, 1999d; 1999b). Teachers instruct the students on usage of textbooks and other learning materials, and students' learning is assessed using standardized testing. *Emancipatory* processes are weakly embedded. Soil (health) education is centred around learning and exploration with an encouragement of participation and engagement however, there is no specific emphasis on critically analysing or challenging issues related to soil (health). The wish is to facilitate soil (health) education through *emancipatory* processes to a greater extent.

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Activities: In primary education, soil (health) education is facilitated predominantly by *Knowing-* and *doing-based* activities. Pupils gain factual information from textbooks, and then engage in hands-on activities, exploration and experimentation to deepen their understanding of soil (health). For example, in Geography, students learn to identify soil components such as peat, clay, silt, sand, and gravel (Department of Education and Science, NCCA, 1999b). In Science, they touch and observe soil, noting differences across habitats (Department of Education and Science, NCCA, 1999d). Students also perform activities such as drawing their observations such as a worm (Department of Education and Science, NCCA, 1999d). *Being-based* activities are weakly embedded, and may be seen as a consequence of *knowing-* and *doing-based* activities that offer an opportunity to connect with the nature (and soil). The wish is to have all the three *Knowing-, doing-* and *being-based activities* in soil (health) education and to use doing- and being-based activities to engage learners and motivate them to went to complete related knowing-based activities.

Paradigm: Soil (health) education in primary schools is approached from a purely *ecological paradigm*. The curriculum encourages activities where students identify the relationships between plants, animals, water, air, and soil in various habitats (Department of Education and Science, NCCA, 1999c). No insights on the wishes for the paradigms were gained.

Gaps, challenges & opportunities

The primary education curriculum in Ireland does not adequately address some of the important soil (health) issues such as desertification, soil sealing, and carbon stocks. In terms of educational design, there is a gap to encouraging students' to explore a personal connection with the soil – the aspect of being.

> Young children love working with the soil. They love mud
> *-A primary teacher (from interviews).*

While the curriculum encourages outdoor learning and an ecological paradigm which aligns with the wishes for the soil (health) education, in practice outdoor learning is limited owing to the financial, logistic and time constraints that teachers and schools often face. Teachers frequently face curriculum overload, and schools struggle with limited funding that restricts outdoor education. In urban areas, there are additional constraints in accessing suitable outdoor environments, and associated logistical costs.

To address these challenges, there is a need for supporting schools financially. Furthermore, there is a need for training teachers in outdoor pedagogy and soil (health) education that enables them to effectively and confidently facilitate outdoor, emancipatory learning experiences. Encouraging peer-to-peer learning among teachers can allow for sharing best practices and experiences. In the current educational framework where students progress is assessed using traditional methods, incorporation of being-based activities presents a challenge. This asks for revisiting how to assess students' progress.

Overcoming these challenges also requires collaborative efforts among educators, NGOs and local community and engagement with real-world projects (e.g. citizen science projects) to help bridge the gap between classroom learning and practical application.

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There are several opportunities to advance soil (health) education towards the wished state. For instance, utilizing school Wellbeing programme time for outdoor learning activities related to soil (health) and engaging students in citizen science projects offer some ways to engage personally with soil. Education programs provided by some NGOs that use an external facilitator on site also offer a way to make an extra staff resource available temporarily.

Secondary education

Vision: To transition towards a curriculum that approaches soil (health) from an ecological paradigm emphasizing the interconnectedness of human and natural systems facilitated through an emphasis on doing and being-based activities and broad collaborations.
Needs: To revise the current curriculum to integrate key soil (health) challenges more explicitly and support teachers with training and resources to enable implementation of the envisioned educational design.
Opportunities: Upcoming introduction of the Climate Action and Sustainable Development subject at the Senior Cycle in 2025 offers an opportunity to embed and expand soil (health) education within secondary education.

State and wishes of soil (health) education

Purpose: Secondary education in Ireland includes a 3-year Junior Cycle, concluding with the Junior Certificate. This is followed by a 2-3 year Senior Cycle with pathways leading to the Leaving Certificate which offers further traditional, vocational, and applied educational options (Irish education system, 2004).

In secondary education in Ireland, key aspects of soil (health) education are integrated into the core curriculum and external programs. It focuses on enhancing students' understanding of soil (health) related to waste management, climate change, biodiversity, and land use, along with an encouragement for critical and solution-oriented thinking with a special focus on organic farming and regenerative agriculture (NCCA, 2024b)

The core curriculum incorporates the Mission Soil objectives of *preventing erosion*, *reducing soil pollution*, *conserving soil organic carbon stocks*, *improving soil structure to enhance biodiversity*, and *reducing soil sealing and reusing urban soils* (NCCA, 2024c; NCCA, 2024d). In external programs, *conserving soil organic carbon stocks* and *improving soil structure to enhance biodiversity* are addressed in sessions focussed on specific goals (e.g. session on carbon sequestration (Green Foundation Ireland, 2022) and through modules such as 'Soils and Soil Stewardship'(Monahan, 2022). *Improving soil literacy in society* is also a prominent focus (e.g. in Climate and Nature Summit, video, 2022). The goals of *reducing soil pollution and enhancing restoration* are weakly embedded in external educational offers, and the goals of *reducing desertification*, and *reducing the EU's global footprint on soils* are not addressed in either core or external offers.

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The curriculum implicitly supports several SDGs, including *zero hunger* (e.g. in the Senior Cycle subject Agriculture, Horticulture which is an option within the Vocational Education element of the Leaving Certificate Applied and incorporates both agriculture and horticulture topics), quality education, *good health and well-being* (e.g. through fostering environmental stewardship and supporting personal well-being in Junior cycle Geography), *life on land* (through a focus on soil composition, formation, and its significance as a natural resource), *climate action* (through a focus on earth processes and human impacts (NCCA, 2024b).

The SDGs *responsible consumption and production* and *economic growth and decent work* are weakly embedded and implicit in Agriculture, Horticulture, Senior School Cycle. (NCCA, 2024b). Other SDGs that include *reducing inequalities* and *no poverty* are absent. The wish is to strengthen the Mission Soil objectives of *improving soil structure to enhance soil biodiversity,* and *Improving soil literacy in society* and the SDGs of *zero hunger, good health and well-being* and *climate action.*

In terms of human development, soil (health) education is predominantly focused on *Knowing* about soil (health) with some focus on *doing* especially in the offers from external organisations. The main purpose is predominantly to learn about soil composition, formation, and its role in the environment. The purpose of *being* is not embedded at all but it was wished by interview participants to be embedded especially attitudes and values.

The wish is to shift towards an approach to soil (health) education where *doing* and *being* are more embedded.

Collaboration: Soil (health) education in secondary schools in the Ireland is primarily *narrow* with some occasional examples of *narrow-broad* collaborations where NGOs and civil society organisations are involved in soil (health) education. *Broad* collaborations are weakly embedded or absent. The wish is to make collaborations *broad*.

Space: Soil (health) education predominantly occurs *indoors* with a focus on understanding soil properties and fertility through experiments and classroom discussions. There are some *outdoor* educational components such as soil sampling and field trips, and some extra-curricular activities in school gardens. The wish is to prioritise *outdoor* education.

Process: The process is mainly *instructive,* which may be attributed to the focus on obtaining the 'Leaving certificate' final qualification which is largely based on traditional assessment methods. *Emancipatory processes* are weakly embedded. The wish is to move towards soil (health) education facilitated using *emancipatory* processes to a greater extent.

> With current leaving cert curriculums, especially in science we're basically just cramming content
> *-A teacher (from interviews).*

Activities: *Knowing-based* activities predominate soil (health) education at secondary level with some *doing*-based activities. *Being-based* activities are rare. The wish is to adopt an approach where *doing- and being-based* activities are more embedded.

Paradigm: The desk research indicated that soil (health) education at secondary education primarily follows an *ecological paradigm*, focusing on the interconnectedness of human

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and natural systems, as seen in geography and science curricula (NCCA 2024c; NCCA, 2024d) Senior Cycle Agricultural Science also incorporates the *mechanistic paradigm* by emphasizing soil composition, nutrient management, and productivity optimization. The interviews however, presented an insight that the *mechanistic paradigm* is more dominant. The wish is to transition towards the *ecological paradigm*.

Gaps, challenges & opportunities

Currently, secondary level education lacks or weakly integrates some of the key known challenges around soil (health) including reducing desertification, and preventing soil pollution, as well as the SDGs that are directly connected to soil (health) such as clean water and sanitation. To bridge the gap between the current knowledge-focused curriculum, which lacks sufficient practical outdoor activities and provides limited opportunities for students to form personal connections with soil, and the desired shift towards prioritizing outdoor, doing, and being-based activities, specific challenges must be addressed. Firstly, the curriculum should incorporate the specific soil (health) related challenges. In addition, teachers need training, perhaps as a part of CPD (Continuous professional development) that enables them to teach soil (health) topics and implement the envisioned aspects of the educational designs effectively. In addition, there is a need to revisit student assessment criteria which currently mainly focusses on traditional knowledge acquisition evaluation and the school leaving certificate final qualification, and is not suitable for assessing performance for instance for being-based activities. Teachers also need a more manageable workload and resources such as outdoor learning spaces and teaching resources for the envisioned approaches, as well as motivation and time to use them.

> Most people are producing excellent resources out there. I think the challenge you'll face is actually getting people to use them
> *-A teacher (from interviews).*

Engaging external organizations such as NGOs and local communities can help with presenting educational resources and learning spaces and bringing contemporary, real-world examples into school teaching. Therefore, such collaborations should be encouraged.

The introduction of the Climate Action and Sustainable Development subject at the Senior Cycle in 2025 offers an opportunity to embed soil (health) education more strongly in secondary education. Additionally, leveraging the flexibility in the Junior Cycle Science curriculum and particularly in the optional Transition Year can help incorporate more soil (health) activities. As with primary school, time in the schedule is allocated to health and wellbeing and this has the potential to be used for soil (health) education and awareness activities.

Tertiary education

Vision: To facilitate increasing soil literacy in society through tertiary level education.
Needs: To encourage and facilitate collaborations both within and outside local universities and educational institutions at both undergraduate and postgraduate levels.

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Opportunities: There are initiatives such as a university soil network that offer opportunities for local collaboration and knowledge sharing from research projects, thus fostering a community of practice and potentially enriching soil (health) education.

State and wishes of soil (health) education

Purpose: Tertiary level education in Ireland includes state-funded universities, technological institutions, and colleges. These institutions offer a range of degree programs (Irish education system, 2004). At tertiary level, the purpose of soil (health) education in Ireland focuses on developing expertise in nutrient cycling, soil degradation prevention, and sustainable management. These courses directly address the EU mission goals of *reducing soil pollution and enhancing restoration, preventing erosion, and improving soil structure to enhance biodiversity,* while the goal of *conserving soil organic carbon stocks* is implicitly emphasized. Undergraduate courses, particularly those in Agriculture and Environmental Management, also address *increasing soil literacy in society* (DIT 2024a; DIT 2024b; TU Dublin, 2024). The goal of *reducing desertification* is weakly and implicitly embedded and *stopping soil sealing and increase re-use of urban soil* is absent. Postgraduate courses explicitly address SDGs in connection to soil (health) and include *zero hunger, clean water and sanitation,* and *responsible consumption and production* (SETU, 2024a). SDGs of *climate action, life on land, and sustainable cities and communities* are implicit in MSc courses such as in Sustainable Development, Horticulture, and MSc(Agr) in Environmental Resource Management (TU Dublin, 2024). At the undergraduate level, specific modules such as GEOL20180 Geoscience Perspectives on the UN Sustainable Development Goals (2024) explicitly cover a broad range of SDGs including *no poverty, zero* hunger and quality *education*. The goal of *peace, justice and strong institutions* is absent. The wish is to emphasize increasing soil literacy in society, while no insights were gained regarding wishes related to SDGs.

In terms of human development, the purpose of soil (health) education is to nurture talents with strong research skills and the ability to address challenges in market-led production, rural enterprises, and environmental sustainability, as seen in programs like BSc (Hons) Sustainable Agriculture (2024). In these courses, the focus is on *knowing* about soil (health) processes, and *doing* i.e. developing practical skills through fieldwork and lab analyses for hands-on experience in soil (health) assessment and ecosystem management. The purpose of *being* is not embedded. No clear insights on this aspect were gained.

Collaboration: Soil (health) education at the tertiary level primarily involves narrow collaborations, occasionally extending to narrow-broad collaborations. For example, as part of the MSc(Agr) Environmental Resource Management course at UCD (2024), some collaborations offer field trips to students. These include visits to the

> In an ideal world, the whole thing would be taught out in the field and they [students] would be interacting with people in agriculture, forestry and recreation.
> *-A university lecturer (from interviews).*

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Agricultural Catchments Programme in Teagasc in Wexford (which compiles data sets on soil and farming practices in 6 Irish catchment areas), and to the Burren (a unique area with Glaciokarst landscape where a Farming for Conservation programme has been initiated) in Co. Clare. There is a wish to broaden the collaborations within and outside university.

Space: Depending on the course module related to soil (health) education both *indoor* (primarily the classrooms and laboratories for lectures, seminars and experiments etc) and *outdoor* learning spaces (e.g. for field studies and practical exercises) are employed to differing extents. For instance, the MSc program in Sustainable Development at TU Dublin (TU Dublin, 2024) and the Carbon and Sustainability module at UCD (UCD, 2024a) emphasize indoor learning spaces, while modules such as Soil (health) and Water Management at SETU and Soil, Plant, and Water Resources in the MSc(Agr) Environmental Resource Management at UCD focus more on outdoor learning, (SETU, 2024a; UCD, 2024b). In some cases, class sizes are very large and this can severely restrict opportunities for outdoor learning. No insights into the wishes could be gained.

Process: There is a predominance of *instructive* processes in tertiary level soil (health) education. The typical process includes lectures, seminars, tutorials and laboratory practicals. *Emancipatory* processes are weakly embedded, for instance in the Undergraduate course in Applied Soil Science module (SETU, 2024b) which is predominantly project based No insights into the wishes could be gained.

Activities: At the tertiary level, soil (health) education predominantly employs *knowing-based* activities like lectures, online resources, writing reports and assignments. These activities are complemented with *doing-based* activities which are sometimes relatively weakly embedded such as field trips, laboratory practical, and projects and presentations. *Being-based* activities are missing. No insights into the wishes could be gained.

Paradigm: In tertiary level soil (health) education, the *ecological* paradigm dominates in most of the available courses (e.g., MSc in Sustainable Development, TU Dublin (TU Dublin, 2024); MSc Horticulture, UCD (UCD, 2024b); MSc Environmental Resource Management, UCD (UCD, 2024c); B.Sc. Agriculture, MTU (MTU, 2024)). These courses address the importance of soil (health) in carbon sequestration, as well as its relationship to climate change, and its broader environmental and social impacts. There are some courses such as the Postgraduate Certificate in Soil (health) and Water Management (SETU, 2024), which follow a predominantly *mechanistic paradigm*. No insights into the wishes could be gained.

Gaps, challenges & opportunities

Because of a lack of insights into the wishes for various dimensions concerning soil (health) educational design, the identification of gaps and needs are based on the desk-research only.

> You have students that are going out. They know what to do. They're very aspirational, but they're heading into businesses and heading into systems that haven't quite had that education piece and haven't moved fast enough
> *-A university lecturer (from interviews).*

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There is a wish to broaden the collaborations within and outside educational institutes. This is particularly important considering that lack of collaborations creates a disconnect between the most pressing real world challenges as students learn from their research and studies, and the challenges that are considered important in different professions (e.g. the food industry or horticulture). Collaborations within universities would foster a transdisciplinary approach and the development of local initiatives.

Vocational educational training (VET)

Vision: To prepare future farmers and horticulturalists that are skilled in sustainable practices concerning soil (health) by strengthening the ecological paradigm in VET courses, encouraging collaboration and creating a focus on the aspect of being.
Needs: To facilitate collaborations between research, advisory services, and education, as well as utilizing government incentives to enhance engagement in soil (health) education
Opportunities: The growing number of VET agricultural students, coupled with government incentives, presents an opportunity to cultivate a new generation of farmers who are both motivated and skilled in adopting pro-soil (health) practices.

State and wishes of soil (health) education

Purpose: In Ireland, soil (health) education is primarily embedded into agricultural, and horticultural courses. Over the recent years, enrolment in agricultural VET programs has observed an increasing trend driven by incentives such as young trained farmer status and associated CAP Pillar I payments (Ireland's Common Agricultural Policy strategic plan's pillar 1 payment covers direct and market supports to consumers, farm families and rural communities by the Irish government) (Flannery et al., 2022). These courses frequently and implicitly address EU mission goals of *conserving soil organic carbon stocks* and *improving soil structure for biodiversity* (Teagasc, 2024a; Teagasc, 2024b, Teagasc, 2024c). Across both agricultural and horticultural programs, there is a strong emphasis on *improving soil literacy in society*. The goals of *reducing desertification*, *reducing soil pollution and enhancing restoration*, and *reducing the EU global soil footprint* are weakly and indirectly embedded, and *stopping soil sealing or increasing urban soil reuse* is absent likely because soil (health) was not considered a topic of concern in urban areas until recently. As awareness of these issues grows, it is anticipated that these crucial aspects will become more prominently featured in future VET curricula. The courses also address how soil (health) is linked to the SDGs of *quality education* and *life on land*, with indirect addressing of *good health and well-being*, *zero hunger, sustainable cities and communities* and *climate action*. SDGs such as reducing inequalities and life below water are weakly embedded in courses such as Applied Permaculture (QQI, 2016a)while some SDGS that include *clean water and sanitation, sustainable cities and communities*, and *partnership for the goals* are absent. No insights on the wishes for the purpose for soil (health) education in terms of Mission Soil objectives or SDGs could be gained.

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In terms of human development, soil (health) education in VET focuses on *knowing* and *doing* which is a consequence of the educational focus on knowledge acquisition as well as skills development for associated vocations. Most VET courses employ practical projects and demonstrations to bridge theory and practice, enabling students to apply their knowledge directly. Examples include sustainable horticultural practices, water management, and runoff reduction (QQI, 2016b). Practical learning is further supported by Teagasc through placements and projects (QQI, 2016a; QQI, 2016c). *Being* is weakly embedded. The wish is to strengthen the purpose of *being*.

> It's very difficult to break it [soil (health)] down to components because everything is interacting anyway.
> *– A Vocational Education manager(from interviews).*

Collaboration: Collaborations in Soil (health) education in VET in Ireland are predominantly *narrow* and primarily involves teacher and students. Occasionally there are *narrow-broad* collaborations for example training days or conferences involving soil (health) researchers and VET educators and farmer advisors. There are often placements, such as those organised by Teagasc which has over 100 active host farm units that provide in situ practical learning periods (placement) for Teagasc learners" (Teagasc College Prospectus, 2024). These, however, are not considered collaborations within the definition provided in this research. *Broad* collaborations are rare. The wish is to have *broad* collaborations.

> The people aren't really understanding how critically important soil functions are for the functioning of the planet.
> -A soil (health) *researcher who liaises with farmer advisors (from interviews).*

Space: Due to the focus on developing professional applied skills, most soil (health) education related VET programs are designed to take place predominantly *outdoors* but also feature *indoor* educational components that occur in classrooms and laboratories. For instance, the course, Applied Permaculture course (QQI, 2016a) includes a range of activities such as research, topic investigation, designing projects, practical exercises, and the creation of artifacts or events. No insights into the wishes could be gained.

Process: In soil (health) education related VET programs, the process is primarily *instructive,* as evident in assessment procedures where instructors design tasks and examinations to evaluate student's learning against a set criteria. *Emancipatory processes* are weakly embedded For example, in the module, Soil Science and Growing Media, the assessment typically includes 20% for assignments, 20% for skills demonstrations, and 60% for a theoretical exam (QQI, 2016d). No insights into the wishes could be gained.

Activities: VET education in Ireland is primarily facilitated by a combination of *knowing*- and *doing-based* activities, with a greater emphasis on doing-based activities with a goal to prepare students with skills required for real-world applications. The degree to which *being-based* activities are employed could not be ascertained. The wish is to strengthen *being-based* activities in VET education.

Paradigm: In VET programs, soil (health) education is approached predominantly from a *mechanistic* paradigm. The *Ecological* paradigm is weakly present, especially in

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horticultural courses that incorporate topics such as biodiversity, nutrient cycling, and soil ecology. (For example, the course, Applied Permaculture, takes an ecological approach to soil (health) topics by addressing ecological principles, sustainability and biodiversity (QQI, 2016a). The wish is to strengthen the *ecological* paradigm.

Gaps, challenges & opportunities

In Ireland, some important challenges surrounding soil (health) such as issues related to urban soil (e.g. soil sealing) should to be more strongly embedded in the VET curriculum, especially as urban soil management becomes increasingly relevant. Furthermore, there is also a need to integrate broader SDGs in the VET courses. There is also a significant gap in the current state of VET education which is focussed on *doing* and *knowing,* and the wish for a strong component of *being*, which is crucial for creating motivation for creating a positive shift to soil (health) conservation. Furthermore, the collaboration in VET primarily limited to students and teachers with some collaboration between researchers and educators but a lack of interdisciplinary partnerships that could enhance sustainability and integrate diverse expertise.

> Everything's interconnected, but I don't think in general humans see that.
> *– An NGO educator (from interviews)*

To address these gaps, there is a need to facilitate collaborations between research, advisory services, and education, as well as utilizing government incentives to enhance engagement in soil (health) education. Additionally, in-service training programs for educators can update and align teaching with the latest research, and leveraging current agricultural education incentives can drive deeper involvement and motivation among learners.

General public

Vision: To empower the general public through soil (health) education that integrates knowing, doing, and being, fostering broad collaborations and experiential learning.
Needs: To create more accessible and engaging soil (health) educational offers that adopt a simple language and integrate foundational knowledge and practical skills within broader ecological contexts.
Opportunities: Some programs involve the public in soil (health) education by offering experiential learning opportunities in outdoor settings, and thus offer a model to expand (e.g. Green cert by Farming for Nature (Farming for Nature, 2023) and training events from Composting Ireland (Composting Ireland, n.d.).

State and wishes of soil (health) education

Purpose: There are only a few offers related to soil (health) education available to the general public in Ireland. These offers aim to promote sustainable agricultural practices and practical strategies for improving soil (health). Additionally, some offers also highlight the therapeutic benefits of working with soil, including mental well-being and social interaction (Greenside Up, n.d.). These offers address Mission Soil objectives of *improving soil literacy in society, preventing erosion, improving soil structure to enhance soil biodiversity, conserving soil organic carbon stocks, reducing soil pollution and enhancing*

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restoration. These offers also implicitly address the SDGs of *zero hunger* (by emphasising the importance of soil (health) for agricultural productivity), *clean water and sanitation*, *climate action* (through soil carbon sequestration, *life on land* (by emphasising the importance of soil (health) for biodiversity in terrestrial ecosystems), as well as *quality*, *good health and well being* (by emphasising the importance of soil (health) for nutritious food production and the therapeutic benefits for mental and physical health). The wish is to strengthen the EU Mission Soil objectives of *reducing desertification, stopping soil sealing and increasing reuse of urban soils, reducing soil pollution and enhancing restoration*. No insights into the wishes for SDGs in soil (health) education were gained.
In terms of human development, the purpose of soil (health) educational resources for the general public is predominantly *knowing.* The desk research indicated that the purpose of *doing* and *being* are weakly embedded. The interviews, however, presented an insight that there are offers where knowing, doing and being-all are present. Examples include those from the Stepping Stones Forest, where knowledge about trees and planting methods is provided, along with encouragement for people to participate in group planting drives (Stepping Stones Forest, 2023). The wish is to continue with a purpose of soil (health) education where all three- *knowing, doing* and *being* are embedded.

Collaboration: The soil (health) related education for the general public is predominantly offered through *narrow* and occasionally *narrow-broad* collaborations. *Broad* collaborations are missing. The apparent wish is to make the collaborations *broad*.

Space: The learning space for soil (health) education for general public is predominantly *indoors* through online textual information and educational videos. However, there are some offers which exclusively occur *outdoors such as practical training events and courses run by Composting Ireland* (Composting Ireland, n.d.). No insights on the wishes could be gained.

Process: Soil (health) awareness offers for the general public are predominately facilitated through *instructive* processes. E*mancipatory* processes are not embedded. . No insights on the wishes could be gained.

Activities: In soil (health) awareness offers for general public, *Knowing-based* activities focussing on providing facts about soil (health) predominate, with weaker components of *doing-based* activities. *Being-based* activities are not embedded. The wish is to facilitate soil (health) education using predominantly *being-based* activities.

Paradigm: Soil (health) awareness offers for general public predominantly adopt the *ecological* paradigm with components of the *mechanistic* paradigm. The offers emphasise the interconnectedness of soil (health) with ecological systems and human well-being, and promote soil management practices such as minimizing chemical inputs, incorporating organic matter to soil and support biodiversity. No insights on the wishes could be gained.

Gaps, challenges & opportunities

There are only a few soil (health) education resources available to the general public. Those available are generally online and provide quite a general overview on soil (health)

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specifically in the context of sustainable farming practices. Due to the online nature of these courses, they provide a certain amount of theoretical knowledge but lack detailed direct application methods potentially limiting the learner's ability to engage with and practice pro-soil (health) practices, as well as in translating awareness into behaviour change. Given most of the offers available to the public occur *indoors*, there is a large gap towards the wish of making it predominantly *outdoor*.

To address these gaps, there is a need to create and offer more soil (health) educational opportunities to the general public and make them more engaging using simple language and integrating more practical exercises. Additionally, to promote the culture of care towards soil (health) and sustainability, the general public also needs policy incentives alongside accessible educational offers that support continuous development (e.g. refresher courses).

> I think just talk to people in plain English and, you know, do things by example rather than a nice fancy chart.
> *–A civil society representative(from interviews).*

An important question that emerged from the desk research is that assessing how well the general public applies instructional knowledge, especially in complex technical processes, remains difficult. Soil (health) focused citizen science projects can engage the public through *doing-*, *being-* and *knowing-based* activities. Creating more Massive Open Online Courses (MOOCs) and other online resources can help bridge the educational resource gap, however these should be made more engaging and thought provoking. In addition, community workshops and partnerships with local organizations can offer more hands-on learning. Furthermore, organizing interactive public events with targeted funding can balance outdoor and indoor education, providing immersive learning experiences.

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A.6. Italy

Soil (health) education in Italy faces substantial gaps and challenges, but there are also promising features to build upon. Current curricula, specifically in primary and secondary schools, are often characterized by a segmented approach that fails to connect the purpose of soil (health) education with the Sustainable Development Goals (SDGs). While primary schools do a good job integrating soil education, knowledge becomes more specialized and fragmented at higher educational levels. In order to emphasize the complexity of soil (health) and its impact in real-world context, education needs to enhance soil literacy and to incorporate experiential educational activities that can foster an active civic engagement. Current programs, mostly in secondary and postsecondary education, emphasize theoretical knowledge. There are instances where non-formal education initiatives and certain innovative schools have successfully incorporated hands-on activities, promoting a deeper understanding of soil as a living ecosystem. However, it is important to enhance forms of collaborations that reduce the reliance on non-formal education. Vocational Education and Training (VET) courses provide exemplary opportunities for the inclusion of social dimension SDGs in soil (health) education in the Italian context. The general public's education on soil (health) shows potential through children's science literature that makes difficult soil topics understandable to a wider audience. To address the current challenges, Italy must enhance partnerships with non-formal learning and with research actors, integrate real-world experiences through partnerships with external stakeholders, and foster a deeper understanding of soil's pivotal role through emancipatory and ecological approaches.

Primary education

Vision: To follow government guidelines and incorporate Agenda 2030 goals, fostering a holistic understanding of soil.
Needs: To integrate primary educational material with collaborative activities and outdoor explorations to help students engage in active citizenship.
Opportunities: Enhancing better forms of partnerships with non-formal education actors while simultaneously reducing dependency on them in soil (health)education. The network of Sustainability Education Centers certainly represents an opportunity in those Italian regions where it is developed extensively. This collaboration promotes synergetic forms of collaboration in which the complementary skills of educators and teachers are integrated in the framework of forward-looking, medium-term projects. Furthermore, non-formal education is flexible and quickly adapts to promote goals set by institutions like the EU, FAO, and UN.

State and wishes of soil (health) education.

Purpose: National Education Curriculum for primary schools in Italy places emphasis on the structural aspects of soil (e.g., soil composition and description of soil strata) and lacks focus on soil (health). The connection of soil (health) with the EU mission objectives — *reducing desertification, reducing soil pollution, stopping soil sealing and increase re-use of urban soils, preventing erosion, improving soil structure to enhance soil biodiversity,*

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and improving soil literacy in society— is established when soil is explored in reference to soil phenomena such as desertification and erosion. In primary schools, soil (health) education mostly prompt pupils to observe soil biodiversity and understand soil as a living ecosystem. For example, in the project "Soil, Skin of the Earth" (CEAS Terre Reggiane – Tresinaro Secchia, 2024) students examine soil biodiversity by looking at macrofauna and mesofauna with the naked eye and using microscopes for smaller organisms, emphasizing the importance of a diverse and structured soil profile (Il Suolo Pelle Della Terra – CEAS Terre Reggiane – Tresinaro Secchia, Retrieved January 17 2024). The linkages between soil (health) and SDGs such as *zero hunger, responsible consumption and production, climate action, life on land, good health and well-being, and sustainable cities and communities* are presented in the curriculum, while broader socioeconomic SDGs are missing. The few textbooks that refer to Agenda 2030 emphasize air and water issues but neglect soil. The current Italian primary school textbooks, due to their mechanistic and compartmentalized approach, fail to convey the interconnected nature of soil with all SDGs. The wish is to place soil (health) at the centre of different subjects and discussions around soil (health) and SDGs together with emphasizing the primary importance of *sustainable cities and communities.*

In terms of human development, the purpose of soil (health) education is focussed primarily on *Knowing.* School textbooks in primary school promote a static and fragmented knowledge of soil. In very few occasions, school materials invite pupils to engage in behaviours that promote soil (health), for instance when instructing them on waste separation. Generally, in the Italian school system, t*he educational purposes of doing and being* are delegated to non-formal education which operates in and with schools through Environmental Education Centres and third-sector entities such as educational cooperatives and associations. For instance, through the project "School in Nature" (CTR Educazione alla sostenibilità Arpae, 2024), the contact with soil is presented in a therapeutic way and connected with its chemical characteristics and involving pupils in real farming activities. These examples exceptionally present forms of *Being* and *Doing,* where non-formal education promotes human skills, knowledge, actions and behaviours, contributing to soil (health) and civic education at the primary level school. There was no clear specific wish regarding purpose in relation to EU deal Missions and Human Development in soil (health) education for primary level.

> Doing is transversal to human development and knowledge development.
> *-A civil society representative (from interviews).*

Collaboration: Soil (health) education in primary schools in Italy is predominantly *Narrow-broad.* Primary school hardly establishes collaborations with agencies, organizations and people working in fields other than education. On the other hand, in the Italian primary school system, a fertile collaboration between institutional education and non-formal education has been established since the 1990s (see e.g. Crescenzo, 2023 and Siamo nati per camminare, 2024). Non-formal education network compensates formal education system for its pedagogical and content deficiencies to the extent possible. The network of

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Sustainability Education Centres, for example, offers a significant opportunity in the Italian regions where it is well-developed. When public authorities provide financial support, the relationship between these centres and classrooms fosters synergetic collaboration, integrating the complementary skills of educators and teachers in medium-term, forward-looking projects. However, in regions where these informal networks are either absent or fragmented, and local public authorities do not provide support, the relationship between schools and non-formal education actors becomes more commercial, leading to fragmented projects (Fellini & Controvento Società Cooperativa Sociale O.N.L.U.S., 2020).. The challenge is to integrate institutional and non-formal education systems more closely and seamlessly so that the positive consequences of this collaboration are less sporadic and allow for more exchanges. The wish is to extend towards a *Broad* collaboration at the primary education level.

Space: Soil (health) education in primary schools in Italy is primarily conducted *indoors*. Primary school guides often encourage teachers to conduct outdoor activities and soil exploration to compensate for the lack in textbooks, but many teachers disregard these guidelines. When outdoor activities are not possible, "bringing the nature indoor" is also valuable. The wish is to offer soil (health) education predominantly *outdoors*.

Process: The approach proposed by the educational material is mainly *Instructive* and only sporadically *Emancipatory.* For instance, when soil (health) education stimulates pupils to undertake experiments on soil, these are limited to studying its composition, without providing room for solution-finding and/or reflection activities. No textbooks reviewed propose studying soil through cooperative learning or peer education, nor do they encourage student research or involvement in citizen science projects. There was no clear specific wish regarding process in soil (health) education at primary level.

Activities: In the primary education, soil (heath) education is facilitated by predominantly *Knowing-based* activities, with components of *doing-based* activities. Despite the scientific evidence and pedagogical guidance, elementary school textbooks focus mainly on theoretical knowledge, with practical, hands-on activities being underrepresented and focused on making students understand mainly soil composition, permeability or sedimentation. *Being-based* activities are generally absent, especially with respect to responsible use and protection/maintenance of healthy soil. Interviews reveal that activities like visual art activities and observing nature, including earthworms, soil, and plants, are fundamental for developing children's observational skills. There was no clear specific wish regarding activities in soil (health) education at primary level.

Paradigm: A review of soil education resources for primary schools indicates a greater emphasis on *mechanistic* paradigm. In general, elementary school textbooks are organized in watertight compartments, and do not consider interdependencies and based on soil classification. Some reviewed texts consider soil's ecosystem function from a non-anthropocentric perspective, while the others do not address ecosystem function at all. In ecosystem descriptions, soil is often neglected. Interviews emphasize the need for human interaction with soil to improve its health and quality, and therefore for a more

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ecological paradigm. There was no clear specific wish regarding paradigm in soil (health) education at primary level.

Gaps, challenges & opportunities

In Italy, primary school educational material mainly uses a *mechanistic* and compartmentalized approach, promoting static knowledge. This method fails to show how soil is connected to all the SDGs. Formal education is rigid and slow to change, while non-formal education is flexible and quickly adapts to promote goals set by institutions like the EU, FAO, and UN. Teachers often pass on topics they find difficult into non-formal educators, and rarely continue these topics in class. Additionally, non-formal education networks are unevenly developed across different regions of Italy. Outdoor educational activities in Italian primary schools are often seen negatively as mere "play." Textbooks frequently ignore or poorly address soil topics due to a lack of focus, of a holistic view, and of a method to tackle complex subjects. Strengthening partnerships with non-formal education providers can bring more expertise and resources into the classroom. This can help cover gaps in formal education and offer diverse learning experiences.

Secondary education

Vision: To promote a holistic understanding of the roles of soil (health) across multiple disciplines.
Needs: To invest in the training of teachers to provide them with the pedagogical tools to foster student development in *knowing, doing*, and *being*.
Opportunities: Fostering collaboration between teachers of different disciplines.

State and wishes of soil (health) education.

Purpose: Secondary education in Italy is divided into two stages: First Grade Secondary School, lasting three years and corresponding to lower secondary school or middle school, and Second Grade Secondary School, lasting five years and corresponding to upper secondary school or high school, which culminates in the Maturity Diploma. First Grade Secondary School offers a general curriculum that is uniform for all students. In contrast, Second Grade Secondary School is divided into three pathways: Professional Institutes, Technical Institutes, and Lyceums, each providing specialized education in different fields of study.

The secondary education in Italy includes soil (health) related topics within different disciplines such as Natural Sciences, Biology, Territorial Agronomic Basis for Plant Production and Agronomic Land Management, but lack dedicated soil programs. The living component of soil is explored in depth only in relation to nitrogen-fixing organisms (improving *soil structure to enhance soil biodiversity*) while in other textbooks, including those adopted by the Agricultural Institute, herbicide pollution is mentioned generically *(reducing soil pollution and enhance restoration*). *Stopping soil sealing and increase re-use of urban soils* and *improving soil literacy in society* are also embedded in soil (health) at secondary education level.

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The correlation between soil (health) and the SDGs is made explicit only in educational material of the First Grade Secondary School (Middle School), particularly relating soil to *sustainable cities and communities, responsible consumption and production, life on land, and climate action*. The Second Grade Secondary School (High School and Technical Institutes) soil (health) education shows no strong relationship between soil (health) and the SDGs. For instance, the textbook "Agronomic Bases of Soil" (Tedeschini and Ferrari, 2023) specifically the chapter "Agriculture and the Environment", gives minimal attention to alternative farming methods like organic, integrated, and biodynamic farming. None of the educational material of the Second Grade Secondary School reviewed relate soil (health) to no p*overty, good health and well-being, quality education, gender equality, clean water and sanitation, affordable and clean energy, decent work and economic growth. life below water, zero hunger, peace, justice, and strong institutions, industry, innovation, and infrastructure, reduce inequalities,* and *partnerships for goals*.

In terms of human development, only First Grade Secondary School aims to develop human beings in the three dimensions of *knowing, doing, and being* through an integrated and structured approach and the construction of critical knowledge. For instance, some schools employ hand-on activities such as horticultural experiments in the school garden and sometimes with visits and workshops at local educational farms. In general, Second Grade Secondary School educational materials focus on *knowing* which is often disconnected from *doing* and *being*, with the exception of books dedicated to ecology and land management. Some types of schools, such as agricultural schools, compensate for the gaps in textbooks by supplementing teaching with hands-on activities in the fields. However, this is rarely done in high schools. In the Italian secondary school system, with the exception of a few innovative educational settings, *doing* and *being* are almost never a priority. The result is a patchwork of realities in which the goals achieved at the end of schooling depend largely on the ability and skills of individual school coordinators and teachers. The wish is to shape soil (health) education through the emphasis on the purpose *sustainable Cities and Communities* and the aspect of *being.*

Collaboration: Soil (health) education in secondary schools in Italy is predominantly *narrow-broad.* First Grade Secondary schools usually collaborate with sustainability education centres (CEAS), educational farms, and other third-sector entities such as educational cooperatives, voluntary associations, and environmental associations. This collaboration brings concreteness to the knowledge transmitted by the institutional school system and allows students to gain practical experience and observations in the field. Second Grade Secondary schools rely on better-prepared internal teachers and focus more on their own methods and standards. Collaboration often takes place with universities and research centres and is developed on specific projects (e.g. Istituto di Istruzione Superiore Rolando Da Piazzola, 2024). The wish is to extend towards *broad* collaboration.

Space: Secondary school curricula and educational materials do not promote *outdoor* activities. These take places mainly on the initiative of the individual teacher or of those

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schools that by orientation support practical forms of learning (e.g., agricultural technical colleges and technical colleges for surveyors). The wish is to have a good combination of *indoor* and *outdoor*.

Process: The process is mainly *instructive,* however recognition of the importance of *emancipatory* approaches, with few non-formal exceptional examples, is evident. The First Grade Secondary School educational material, at times, stimulate an *emancipatory process*, while most of the Second Grade Secondary School textbooks facilitate an *instructive process*. There was no clear specific wish regarding process in soil (health) education at secondary level.

> The educational part is partly there, but it must be combined with the experience of a natural context. This is what we normally propose as CEAS.
> *- Coordinator of a municipal sustainability education center (from interviews).*

Activities: *Knowing-based activities* predominate soil (health) education, with exceptions of some cases of *doing-based activities* where students are invited to perform experiments. *Knowing-based activities* involve acquiring knowledge passively which, if not supplemented by practical proposals from teachers and not accompanied by classroom debates and discussions, may remain disconnected from reality. Many textbooks start with questions that invite students to deepen their knowledge. They alternate paragraphs that impart soil (health) knowledge (*knowing*) with sections that invite students to perform experiments (*doing*), conduct collaborative topical research, and present results publicly (*being*). *Being-based* activities are weakly embedded. The wish is to adopt an approach where *being-based and doing-based activities* are more incorporated. There is the desire to emphasize the importance of practical experimentation, manual work, laboratory activities, and fieldwork, such as observing and understanding soil erosion and directly engaging with the terrain.

> We definitely develop mainly the practical and laboratory part, exploring environments through walks. We walk around and look at the urban context and reason about permeable/impermeable soils.
> *- Coordinator of a municipal sustainability education center (from interviews).*

Paradigm: Soil (health) education within national curriculum for secondary education has a dominance of *mechanistic* paradigm. The *ecological* paradigm remains an assumption that is still poorly integrated into the development of educational material, and even the word ecology and interdependency appear little present. In First Grade Secondary School (Middle School), school textbooks are constructed according to an *ecological paradigm*. Soil (health) education addresses mostly the impacts of anthropogenic activities on soil and related natural and anthropogenic ecosystems. Synergies, interdependencies, cause-effect relationships, and transformations are emphasized. In Second Grade Secondary School (Liceo and Technical Institutes) knowledge is highly compartmentalized. In general, they are designed with a *mechanistic paradigm*. They are specialized, and soil is explained from a physico-chemical point of view and through classification. In the school textbooks of high schools and technical institutes, soil and its health are addressed with an *ecological paradigm* only in the course books of

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"Geopedology, Ecology, Territory" (adopted by the Technical Institute for Surveyors) and "Management of the Environment and Territory" (adopted by the Technical Agricultural Institute). The wish is to have an *ecological paradigm* to shape soil (health) education. A greater integration of disciplines, including literary subjects, is needed to create more cohesive and interconnected learning experiences.

Gaps, challenges & opportunities

The crisis in the publishing industry has exacerbated long-standing issues in updating school textbooks. Historically, publishers avoided confronting teacher conservatism by not updating educational material. As a result, textbooks often contain outdated content, also in relation to soil (health) education. Furthermore, The Italian Ministry of Education and Merit indirectly influences publishing houses through guidelines directed at schools and teachers for selecting school textbooks (see ministerial circulars: Italian Ministry of Education and Merit, 18/07/2024). Publishing houses must align with the Ministry's guidelines to remain competitive in the market. One of the primary challenges in soil (health) education is promoting collaboration among teachers of different subjects. This lack of collaboration disables cross-cutting soil (health) knowledge. Although the value of outdoor learning is recognized, many teachers feel inadequate for effective outdoor education. School textbooks reflect Italy's lack of ecological awareness, as noted by some members of the Italian Community of Practice: he meaning of "ecology" has been distorted over the years, losing its complexity. The challenge is to convey soil (health) knowledge through an ecological lens, helping students understand the relationships between soil, ecosystem components, and human health. Teachers feel pressured to stick to predetermined learning programs, limiting opportunities for students to engage in exciting, hands-on learning experiences. Enhancing partnerships with non-formal education networks and interdisciplinary learning approaches represent a significant opportunity for soil (health) education at secondary level.

Tertiary education

Vision: Soil (health) education at the tertiary level in Italy should incorporate an ecological paradigm, highlighting the interconnectedness of soil with other ecological and human systems.
Needs: There is a need for strong investment in professional training for university educators to equip them with tools to support student development integrating knowing, doing, and being elements.
Opportunities: Fostering interdisciplinary collaboration between departments with strong expertise.

State and wishes of soil (health) education.

Purpose: At the tertiary level the purpose of soil (health) education varies by faculty or department. The descriptors found to be predominantly embedded are *stopping soil sealing and increase re-use of urban soils* in courses related to Urban Planning, for example, (e.g. University of Brescia, 2023a) and improving soil structure to enhance soil

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biodiversity in programmes such as Green infrastructures and nature-based solutions (e.g. University of Padova, 2023 and University of Milano, 2023a). In faculties of agricultural sciences, the main focus is on soil fertility in terms of plant mineral nutrition, element cycle in the soil, fertilizer and their legislation (see University of Bologna, 2023a). The descriptors that were found to be weakly embedded are *improving soil literacy in society, reducing desertification, preventing erosion, reducing soil pollution and enhance restoration and conserving soil organic carbon stocks*. Whereas, *reducing the EU global footprint on soils* is not embedded in soil (health) education.

A few recently developed courses (see University of Brescia, 2023b) cover the issues of assessing soil system responses to climate change (*climate action*) and technologies for mitigating climate impact, understanding technologies useful for evaluating soil quality and the impact of soil pollution. Also, there are just a few examples of courses in which the hydrological properties of soils (*clean water and sanitation)* are linked with the topic of soil (health) (e.g. University of Brescia, 2023c.) In terms of the SDGs, soil (health) links predominantly to *sustainable cities and communities* (e.g. University of Bologna, 2023b and University of Brescia, 2023d), *zero hunger* (e.g. University of Milano, 2023b), *no poverty, good health and well*-being, climate *action,* and *industry innovation and infrastructure. Good health and well-being,* and *reduced inequalities* are wished to be more incorporated when shaping soil (health) education purpose.

In terms of human development, the purpose of soil (health) education is primarily focussed on acquiring theoretical knowledge (*knowing*). However, students complain about the lack of practical projects (*doing)*, especially in subjects related to soil, which require more fieldwork and direct interaction with soil. *Being* as purpose is not embedded in the curriculum. *Being* and *doing,* are wished to be more incorporated when shaping soil (health) education purpose.

Collaboration: Tertiary level soil (health) education is characterised by a *narrow* collaboration. In the majority of cases, university teaching is provided solely by lecturers without the involvement of external stakeholders; soil scientists teach "soil students." In exceptional cases, courses include seminars where experts on specific topics, industry professionals, or local policymakers are invited. The challenge is to stimulate the creation of networks of stakeholders that support educational activities by providing opportunities for collaboration and to expand these networks. The wish is to shift towards a *broad* collaboration.

> In our activity, we work a lot with schools, and we also work a bit with citizens through composting courses. However, I would really love to collaborate with universities, where there are structured competencies.
> *-A cCoordinator of a municipal sustainability*

Space: The predominant learning space for soil (health) education at tertiary level is *indoor*. The majority of lecture hours are always dedicated to frontal teaching in the classroom. In many courses, laboratory exercises are included (e.g. University of Bologna, 2023c), with rare examples of field activities (see University of Milano, 2023c). There was no clear specific wish regarding learning space in soil (health) education at tertiary level.

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Process: The process is mainly *instructive*. Teachers find it difficult to prompt students' involvement due to their traditional teaching approach and training. The wish is to facilitate soil (health) education predominantly via *emancipatory* processes, where students can be more easily involved in "soil debates".

Activities: At the tertiary level of education in Italy, soil (health) education primarily emphasizes *knowing-based* activities The main challenge at the university level could be to find the right balance between transmitting necessary knowledge and engaging in activities, such as group work, that stimulate critical thinking and awareness of the importance of healthy soils. The descriptor that was found to be weakly embedded is *being-based activities*. No insights into the wishes on this aspect were gained.

Paradigm: The *mechanistic* paradigm mainly characterizes soil (health) education in tertiary level. In the field of agricultural sciences, there is a growing emphasis on the *ecological* paradigm, which highlights the interconnectedness and interdependence of living organisms and their environment. This approach recognizes the importance of understanding ecosystems as complex systems where organisms interact with each other and their physical surroundings (University of Brescia, 2023e). The wish is to transition towards *ecological paradigm*.

Gaps, challenges & opportunities

Soil (health) education at the tertiary level, in Italy, faces various gaps and challenges, but there are also chances for improvement. One of these challenges is the current focus on theoretical knowledge over real-world experience. University teaching is often delivered exclusively by lecturers without the involvement of outside parties. This leads to a curriculum that is strongly focused on knowledge transmission, with too little emphasis on practical experiences and fieldwork that are essential for understanding soil (health). Another significant gap is the inadequate integration of the *ecological paradigm* into the formal curriculum. Without this perspective, students may lack a comprehensive understanding of soil (health) and its broader implications. Students' capacity to perceive the wider picture and understand how soil interacts with other systems is limited by this siloed approach. There is a notable lack of *being-based activities*, and of *being* as purpose of soil (health) education, that can promote students' individual growth and ethical reflections in relation to soil stewardship. One opportunity is to encourage the development of stakeholders 'network that support educational activities. This includes incorporating external experts, industry professionals, and policymakers in the curriculum to provide students with real-world experiences and perspectives. Universities should also promote multidisciplinary collaboration, giving students the opportunity to work in complex projects that illustrate the connection between soil (health) and other fields.

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Vocational educational training (VET)

Vision: Emphasize soil as a vital source of life and promote mindful, conscious behaviour towards it through education.
Needs: Enhance practical, hands-on soil (health) education and reduce reliance on online formats.
Opportunities: Utilize the effective collaboration in agronomist training, with the national order coordinating regional educational programs.

State and wishes of soil (health) education.

Purpose: National Education Curriculum for VET in Italy places emphasis mainly on *conserving soil organic carbon stocks* and to a large extent on evolving complexities of soil degradation and contamination. Consequently, VET education has the purpose to train future agronomists to implement effective soil (health) management strategies. While the desk research presents *improving soil literacy in society* as weakly embedded in soil (health) education, interviews reveal various EU soil deal missions as integrated part of VET education. These goals include *reducing desertification, conserving soil organic carbon stocks, stopping soil sealing and increase re-use of urban soils, reducing soil pollution and enhance restoration, preventing erosion, improving soil structure to enhance soil biodiversity,* and *improving soil literacy in society.* Whereas specific references to SDGs were not found in soil (health) educational material, interviews reveal a wider connection between soil (health) and these global objectives, promoted by non-formal initiatives. Soil (health), in VET training, is often connected with healthier animals and plants (*life on land)* and *good health and well-being.* The social dimension of SDGs also finds space in VET education and non-formal initiatives, such as the project "Women in the Field." This initiative highlights the important role of women (*gender issues*) in agriculture: women are essential entrepreneurs and guardians of the land, focusing on maintaining soil (health). Non formal educational initiatives at VET level also embed SDGs such as *zero hunger, good health and well-being, decent work and economic growth, responsible consumption and production, no poverty, and climate action.*

> The nature of soil fits with so many goals of the 2030 Agenda, ranging from health to food-Think about polluted soils. How much do they compromise people's health? -For example, if we talk about soil fertility, increasing soil fertility or conserving soil fertility actually means fighting poverty, but it also means carrying with it extremely important social aspects.
> *–A regional environmental prevention agency communications manager (from interviews).*

> The purpose is to highlight that soil is not just a physical support, but the main source of life on which we depend. It is crucial to communicate this at the educational level, as soil is often seen merely as something to step on. Agricultural soils are valued, but other soils are not.
> *-A fFarmer trainer (from interviews)*

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In terms of human development, soil (health) education in VET focuses on *knowing*. Interviews, instead, reveal a better integration of *knowing, doing,* and *being*. No insights in the wishes for these aspects on purpose for soil (health) education could be gained.

Collaboration: Educational material indicated that collaborations in soil (health) education at VET level, in Italy, are narrow-broad, while interviewees' perception of such collaboration is broad. The ongoing training of agronomists demonstrates effective collaboration with the national order acting as a central hub for the educational programs offered by individual regional orders, each governed by a regional territorial council as part of the national professional association for agronomists and farmers. This ensures that the online seminars are accessible nationwide. In non-formal initiatives, collaboration can occur between farmers, technicians, and researchers who set up and conduct the experimental trials in the educational setting. There is the need to broaden collaboration, as support from research and tertiary level institutions is minimal. No insights in the wishes for these aspects on collaboration for soil (health) education could be gained.

Space: Most soil (health) education related VET programs are designed to take place *indoors*. These courses include seminars, mostly online, aimed at enhancing knowledge on specific topics rather than developing competencies and skills. Interviews, instead, report that soil (health) education take place both *indoor* and *outdoor.* Soil (health) education, at VET level, occurs mainly in training institutions, sometimes extending to social cooperatives and Agri-tourism of the area. *Outdoor* activities such as field demonstrations are organized by affiliated research organizations and used to display experimental practices. The on-site learning creates opportunities to involves farmers and other stakeholders from the agricultural sector. The wish is to operate soil (health) education *outdoor* and in the real- world context.

> The spaces I wish to operate in are the spaces where people can understand the importance of what is under their feet and the complexity of things. It is precisely from proximity that we grasp the importance of things.
> - *Regional environmental prevention agency communications manager (from interviews)*

Process: In soil (health) education related VET programs, both *instructive* and *emancipatory* processes are present. Activities are designed in order to be 'transformative' (e.g., transforming the way of seeing and approaching the soil, cultivating the land, managing the soil, etc.), processing a change that entails a profound and enduring alteration at the individual, institutional, and/or systemic levels, through the involvement of different practitioners in the agricultural sector. Stakeholders, in VET educational level, claim how hands-on activities foster *emancipatory* processes in soil (health) education. The wish is to further emphasize *emancipatory* process in soil (health) education.

Activities: The VET education in Italy is primarily facilitated by *knowing- based activities*, however, the insights gained from interviews indicate that there is dominance of *doing-based and being-based*. Agricultural training relies heavily on imitation. Explaining farming techniques becomes much more effective when demonstrated by experienced

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farmers. The wish is to include more *being-based activities* in soil (health) education. There is a clear desire to promote activities that develop mindfulness and awareness of the land among learners. This includes educating individuals to behave consciously on the soil by listening to its needs. It underlines the importance of careful fertilization, of protecting soil from damaging human interference, and of keeping the land productive and profitable.

Paradigm: In VET programs, soil (health) education is approached predominantly from a *mechanistic* paradigm, while it is evident there is a progressing shift toward an *ecological* paradigm. The wish to integrate the *ecological* paradigm does not encounter few challenges. The *mechanistic* paradigm places maximizing yield and production as primary focus of soil (health) education at VET level. In this context, soil is viewed mainly as a means to produce large quantities of crops and as an economic resource. Therefore, the challenge is how to keep the two paradigms together to favour VET education that boosts healthy soils.

Gaps, challenges & opportunities

In Italy, VET soil (health) education programs are offered as online seminars that focus on agriculture subjects. While these seminars include industry professionals, they limit hands-on learning opportunities, which are crucial for developing practical skills in land and agriculture management. The courses enhance knowledge on soil (health) specific topics but often overlook the development of practical skills. A key challenge is to underline that soil is our primary source of life and not only a physical support. Educating VET students about soil's vital functions can shift their perspectives, moving beyond the view of soil only as a base for construction or agriculture. Soil (health) education should also incorporate the idea of "social landscapes," recognizing that landscapes are shaped by both physical features and the people who live and interact with them. This *ecological* view is essential for developing and managing soil in a way that honors its complexity and diversity. A significant opportunity in VET is the incorporation of the socio-economic dimensions of the SDGs into soil (health) education, which is unique compared to other educational levels. VET educational level offers a platform to promote soil (health) through these social goals.

General public

Vision: to integrate outdoor components into soil (health) education, connecting it to the SDG goal of sustainable cities and communities, and promoting responsible, sustainable citizenship.

Needs: to promote a stronger exchange with research actors and academics, and to enhance a more comprehensive and cohesive understanding of soil (health) among the general public.

Opportunities: Enhancing collaborations related to tourism and education to raise awareness and foster responsibility towards soil (health).

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State and wishes of soil (health) education.

Purpose: Due to growing awareness of environmental issues, there has been a shift towards creating new formats and content that deal with soil (health) complexity, future scenarios, and solutions. For instance, recent children's books are now addressing the complexities of soil and underground life, encouraging children to use land consciously and sustainably. Environmental literature, and consequently educational material about soil, is becoming political again, encouraging both collective and individual behaviour. The main themes discussed in soil (health) education, addressing the general public, are connected to soil biodiversity, soil consumption, and agriculture. The main purpose is to make users and learners aware of their responsibility in conserving and protecting soil resources. Educational materials for the general public (e.g. Sapereambiente, 2024; Stradenuove, 2024) address soil (health) in connection with the following EU deal mission goals: *reducing desertification, conserving soil organic carbon stocks, stopping soil sealing and increase re-use of urban soils, reducing soil pollution and enhance restoration, preventing erosion, improving soil structure to enhance soil biodiversity, reducing the EU global footprint on soils,* and *improving soil literacy in society*. Generally, the most discussed topic in educational material addressing the general public and/or in "cultural products" (such as, books, videos, podcasts, broadcasts, websites) is soil biodiversity (*life on land).* Sometimes soil is treated in relation to consumption *(responsible consumption and production)* both in urban and agriculture context (*sustainable cities and communities)* and in connection with soil fertility for food production (*zero hunger*). The connection between soil (health) and *climate action* and *good health and well-being* is sporadically addressed.

In terms of human development, the purpose seems to be *knowing*. Books addressing the general public have the main function of imparting knowledge, while a small part of this type of educational material aims at teaching sustainable practices in the field of agriculture or alternative farming. *Being* is mostly absent and also the most critical to address due to the lack of adequate pedagogical tools. *Being* and *doing* are weakly embedded yet remain the most critical aspects to address due to the lack of adequate pedagogical tools. However, children's books occasionally address both *doing* and *being*, making them somewhat 'political' as they promote different paradigms, values, and lifestyles. Educational materials aimed at children (e.g., Sapereambiente, 2024) foster citizenship action and a sense of responsibility more courageously, perhaps because of fewer political implications. Adult books are predominantly focused on knowledge transmission, except for niche or politicized texts. Most practical knowledge (*doing)*, however, is conveyed through video tutorials and online courses, which are better suited for demonstrating how to do things. In many cases, simple solutions to everyday problems, such as in home horticulture, are shared through short videos on Instagram, where professionals like agronomists, horticulturists, or enthusiasts share their experiences. Interviews insights reveal some cases in which *being* and *doing* are fostered. The podcast "Paesaggi sensibili: proposte per una comunità sostenibile" (translation: Sensitive Landscapes: Proposals for a Sustainable Community), is a notable example,

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where knowledge (*knowing),* practical experience (*doing*) and critical thinking (*being*) are all present, and different experts are interviewed on environmental and soil (health) related topics.

The wish regarding the purpose of soil (health) education is reinforcing the connection between soil (health) and *sustainable cities and communities*.

Collaboration: The soil (health) related education for the general public is predominantly offered through *narrow-broad* collaborations. General public initiatives offer opportunities of dialogue between academic research and education and informal-alternative global culture education. The biggest challenge consists in involving citizens, policymakers, and urban planners in these media-promoted debates. Other sectors, strictly connected with soil (health), such as industry, agriculture, and tertiary sectors are excluded from these discussions. The insights from the interview reveal broader collaboration in the context of general public education. Various projects on soil (health) education foster collaborations among municipalities, municipal libraries hosting workshops, garden projects exploring environments, and collaborations with ecological guards and local associations. The wished form of collaboration is *broad*. For example, it is noted an effort in fostering collaboration with the tourism sector, aiming to raise awareness among citizens and tourists about soil (health) issues.

Space: Soil (health) education for the general public consists of *indoor* and *outdoor* educational activities. Most books, other than manuals, promote knowledge based on reading text and looking at pictures, graphs and maps. Popular books for adults can present interesting and thought-provoking research scenarios but are often difficult to access for those without a specific interest in soil (health)or resource management. They focus primarily on theoretical knowledge and rarely encourage outdoor experiences. In contrast, educational platforms promoting citizen science invite the public to engage in practical, outdoor experiences: manuals, video tutorials and video courses, especially in agriculture, promote hands-on outdoor activities. Videos posted on Instagram often invite reproducing experiences and trying out practical solutions at outdoor activities. However, it is unclear whether these experiences remain a nice episode in participants' lives or stimulate real knowledge and lasting impact. The wish is to have more *outdoor* components, such as social gardens and neglected urban areas, like traffic circles and flowerbeds, that have the opportunity to become places of regeneration and relaxation for citizens.

Process: Soil (health) awareness offers for general public are generally facilitated through combination of both *instructive*, mostly in books, and *emancipatory* processes, when approaching video educational materials. There is a significant number of online videos that teach how to actively carry out practical activities in fields such as alternative agriculture. Promoting emancipatory processes remains the ultimate goal of most educational and publishing initiatives, but also the most difficult to achieve due to lack of pedagogical strategy and specific tools and skills. The wish is to enhance the *emancipatory* process in soil (health) education.

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Activities: In soil (health) awareness offers for general public, a combination of *knowing-based*, *doing-based* and *being-based activities is* adopted. *Being-based activities* are the most difficult to develop, as they are meant to build citizens awareness through experience and involvement. The wish is for a soil (health) education that includes more *doing-based and being-based activities*. Combining hands-on experiences with academic learning, such as field trips to analyse soil profiles and debate issues like desertification can foster a deeper understanding and personal connection with soil.

Paradigm: Soil (health) awareness offers for general public adopt predominantly a *mechanistic* paradigm. There is a growing tendency to adopt a more *ecological paradigm*, mostly for educational media material. This is because knowledge, in the general public scenario in Italy, became divided into very narrow and specialized areas rather than representing soil (health) in its complexity. The wish is to emphasize further the *ecological* paradigm.

Gaps, challenges & opportunities

The challenge of soil (health) education at the general public level now is to re-shape thinking and education in a transdisciplinary way. Making the public aware about soil can lead to better improved actions to protect soil (health). Adult education material often provides fragmented knowledge through different channels, obstructing the development of a comprehensive knowledge framework about soil. On the other hand, children's science literature advances the field by making difficult topics accessible to a large audience, including adults, through simple language and appealing illustrations. This approach can be expanded to the adult audience to develop a deeper understanding of soil. The main challenge is to make the general public aware of the major implications that deteriorating soil (health) can have environmentally, socially, and economically. This means understanding how soil degradation affects livability, poverty, and conflicts, and fostering a connection with the social context of the SDGs. Opportunities for exploring different soil contexts, such as farms or urban areas with limited soil, are necessary. Involving citizens in activities where they feel personally connected is fundamental. Educational materials that promote responsible and sustainable citizenship actions promoting soil (health) are difficult to be found. Broadening collaboration efforts to include public administration as partners on soil (health) education can also be advantageous.

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A.7. Lithuania

Soil (health) related topics are present at different educational levels, with a varying degrees of content depth and teaching approaches according to the educational goals. In primary education, soil (health) is connected to broader environmental education, focusing on basic concepts and its environmental importance. In secondary education, soil (health) is integrated within biology and geography courses, with a greater specificity on soil properties, processes and its roles in ecosystems, agriculture, and sustainability. At the tertiary level, departments of universities and other higher education institutions, specializing in geography, biology, agriculture, and environmental protection, offer in-depth courses on soil (health), addressing key challenges such as soil degradation, conservation, and management. VET curricula, including those on agriculture and horticulture, have very weak focus on soil (health). There is dearth of soil (health) educational offers available to the general public except for farmers, where some offers are available though limited to the agricultural context.

Despite the varying degrees of focus on soil (health), there is a recognition and hence a wish to incorporate soil (health) as crucial component in environmental education. There is an overarching wish across educational levels to make soil (health) education more engaging through hands-on, outdoor learning experiences, particularly in primary and secondary education, and to adopt innovative technological tools in tertiary education. Secondary education is envisioned to benefit from a more focused and interdisciplinary curriculum by linking soil (health) with subjects like chemistry, biology, and geography. Updating teaching materials to reflect the latest scientific research and environmental challenges is also necessary. There is also a general wish to create broader collaboration for soil (health) education and to engage industry, NGOs, and policymakers.

> We should legalise teaching about Lithuanian nature.
> - *Biology teacher (from focus group)*

Methodological considerations: Due to the limited relevance or expertise among teachers, efforts to engage them in discussions about soil (health) education at the primary and VET levels were unsuccessful. Consequently, interviews with teachers at these levels were not feasible. The subsequent analysis is primarily grounded in desktop research and focus group discussions.

Primary education

Vision: No insights on the vision could be gained.
Needs: To incorporate soil (health) topics into the curriculum.
Opportunities: Existing collaborative initiatives between educators, NGOs, and environmental organizations which offer opportunities to embed soil (health) education at the primary level.

State and wishes of soil (health) education.

Purpose: Soil (health) and sustainability education are relatively new developments in Lithuania, as all identified educational resources and programs on this subject date back to 2021 or later. The National Curriculum was only recently updated (in 2023) and it highlights the importance of natural resources, including water, air, and soil, emphasizing

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their role in supporting living organisms and focusing on pollution issues. The older curriculum did not address soil (health) (Jurkevičiūtė & Makarskaitė-Petkevičienė, 2017). However, these changes have yet to be reflected in primary school textbooks, and currently, soil (health) is not included in officially approved primary school textbooks. Nevertheless, soil (health) is covered in a series of methodological publications on sustainability for teachers and students, aimed at preschool and primary school levels. Although these books lack official textbook status, they are still used by educators. Out of 28 books in the series, soil (health) is mentioned in 9. These books emphasize the Mission Soil objectives of *reducing soil pollution and enhance restoration* and *preventing erosion*. For instance, a pupil workbook includes an experiment on soil erosion (Bilbokaitė et al., 2003c) and discusses the soil pollution resulting from improper disposal of medicine (Bilbokaitė et al., 2023d). These books also address the EU mission goals of *reducing desertification* and *improving soil structure to enhance soil biodiversity* (Bilbokaitė et al., 2023ab). Other Mission Soil objectives are absent.

In these methodological books, soil (health) education is also presented as a relevant topic within the context of SDGs, with a focus on *no poverty, sustainable cities and communities*, and *responsible consumption and production*. For example, Bilbokaitė et al. (2023b) illustrates the interrelation of these SDGs and how soil (health) sits within these relationships. They mention that poverty reduction requires environmental and resource sustainability, but increasing food production can harm soil (health) unless farming and consumption practices change.

In terms of human development, the purpose of soil (health) education primarily is *Knowing*. Though relatively less than *knowing*, *doing* is also well embedded, as the educational goals mentioned in the books is to facilitate behavioural change (e.g., proper medicine disposal to prevent soil pollution). The books emphasize that achieving sustainability requires positive changes in ecological, cultural, and social areas (Bilbokaitė et al., 2023a). The purpose of *being* is relatively weakly embedded, considering that the ultimate goal of the education as mentioned in books is developing moral values and attitudes of care towards the nature and Earth, including soil (health). It is reflected in the title of one of the books: "Children Hug the Earth".

Collaboration: Review of educational materials in Lithuania revealed no incentives or examples of collaboration in soil (health) education at the primary level suggesting predominantly *narrow* collaboration in soil (health) educations at primary education level. *Narrow-broad* and *broad* collaborations are absent.

Space: Soil (health) education in primary schools in Lithuania is primarily conducted *indoors* and include resources such as books as well as some hand-on activities inside classroom (e.g., observing soil conditions within a controlled environment like a plastic bottle). *Outdoor* education is weaky embedded. While the Lithuanian National Education Agency with the Lithuanian Agency for Informal Education provides methodological guidance on creating *outdoor* educational spaces (Gerulaitis et al., 2003), and some schools, with support from local authorities (e.g., Vilnius Municipalitysee "Įgyvendinta Vilniaus miesto",

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), are creating *outdoor* learning spaces for soil (health) education, these initiatives are not a common.

Process: Soil (health) education for primary schools in the Lithuania are primarily facilitated through *instructive* processes.

Activities: Currently there is no information on the types of activities that will be included in the official primary school textbooks to comply with the revised national curriculum. The methodological book series on sustainability which address soil (health) as well as informal educational activities (e.g., Vilnius City Municipality-supported projects) related to soil (health) education employ *knowing*- and *doing-based* activities are employed for soil (health) education. *Doing-based* activities include experiments to investigate soil life, soil erosion, and soil acidity, and to discuss preferred soil types for plants (Balbokaite R. et al., 2003c). *Being-based* activities were found to be absent.

Paradigm: A review of soil education resources for primary schools indicates a greater emphasis on *ecological* paradigm as teaching materials emphasise the human influence on nature and Earth. This focus is likely influenced by the overarching theme of sustainability in the reviewed methodological materials that also cover soil (health) topics. No evidence of explicit *mechanistic paradigm* within soil (health) education could be found.

Gaps, challenges & opportunities

Soil (health) is not included in the primary school textbooks, despite its importance in the updated National Curriculum, thus potentially creating inconsistencies in soil (health) education teaching across schools. Due to the lack of insights into the wishes or desirable changes for the soil (health) education at primary level, specific gaps on specific aspects of analytical dimensions cannot be pinpointed. Nevertheless, there are examples of collaborative initiatives between educators, NGOs, and environmental organizations which offer opportunities to embed soil (health) education at the primary level.

Secondary education

Vision: To integrate a comprehensive and ecological perspective on soil (health) into the curriculum, aligning with Mission Soil objectives and SDGs.

Needs: A revision of the secondary school curriculum to strengthen the focus on soil (health) aligned with Mission Soil objectives and SDGs and creation of engaging soil (health) learning resources.

Opportunities: Existing school gardens can serve as outdoor learning environments that address safety concerns and provide practical soil (health) education, offering a model for schools lacking such spaces.

State and wishes of soil (health) education.

Purpose: The National Curriculum in Lithuania for secondary education includes soil (health)-related topics across Biology, Chemistry, and Geography. While it is unclear how these topics will be addressed in the new textbooks following the recent curriculum revision, the

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reviewed secondary school textbooks (based on the older curriculum) address topics that align with several Mission Soil objectives, such as *reducing desertification, preventing erosion*, *reducing pollution and enhancing restoration*, and *conserving soil organic carbon stocks*, with a strong focus on *soil erosion* (*Mader, 2002; Molienė & Molis 2000; Molienė & Molis, 2005; Šalna et al., 2010; Waugh 2002; Williams, 2007; etc.*). *Reducing soil pollution* is also commonly addressed. Rest of the Mission Soil objectives that include *improving soil structure to enhance soil biodiversity*, *reducing the EU global footprint on soils,* and *improving soil literacy in society* are absent.

The textbooks also address, albeit indirectly, several SDGs in connection to soil (health). These SDGs include *responsible consumption and production*, and *good health and well-being* by discussing the consequences of irresponsible farming practices. For example, biology textbooks (e.g. Molienė, Molis, 2000; Williams, 2007) compare intensive monoculture farming with crop rotation, which naturally improves soil fertility and structure and is more pest-resistant. It also shows how certain farming practices can cause soil erosion and water pollution. Other SDGs are absent.

The wish is to strengthen the goals of *reducing soil pollution and enhancing restoration*, *good health and well-being*, and *sustainable cities and communities* in soil (health) education with the same level of focus as is given to clean water and clean air.

In terms of human development, the soil (health) education is predominantly focused on *knowing* about soil (health) within the context of specific subject. *Doing* and *being* are further weakly embedded. While the national curriculum emphasizes development of civic competencies such as social responsibility, resource-conscious consumption, and participation in environmental initiatives, especially in biology and geography lessons, the textbooks mainly focus on knowledge transfer. Exercises in the textbooks often revolve around theoretical knowledge to consolidate learning, with limited practical application. For example, one exercise prompts pupils to respond to a scenario involving environmental pollution, while another involves project work on environmental data (Mikulevičiūtė et al., 2007; Lekevičius & Ignatavičius 2003). Although these exercises do not directly address soil (health) issues, they offer transferable skills. Geography textbooks, despite their extensive coverage of soil (health), also do not incorporate *doing* and *being* components. The wish is to strengthen the purpose of *being*.

Collaboration: Collaboration in the area of soil (health) education in secondary schools in Lithuania is predominantly *narrow-broad*. The textbooks lack activities that could be followed for collaborating with external institutions. While some environmental education collaborations between schools and entities like city gardens and universities exist, their prevalence is unclear. One example of such collaboration includes a school excursion to Vytautas Magnus University's mineralogy lab, where students learned about soil formation, types, and pollution effects (Patirtinis ugdymas, 2019). Additionally, the university offers face-to-face or online lectures for secondary students on soil-related topics ("Vytauto Didžiojo Universiteto paskaitos", 2024). *Narrow* and *broad* collaborations are missing. The wish is to achieve *broad* collaborations in soil (health) education at secondary level. Specific wishes to collaborate with farmers and universities for providing

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students with engaging, practical experiences, to adopt more visual and interesting ways of engaging students were expressed during focus group.

Space: Soil (health) education predominantly occurs *indoors* and typically includes knowledge transfer activities within the classrooms (e.g., reading textbooks). *Outdoor* activities such as taking soil samples are indicated in textbooks, however these are scarce and their application is further limited by the availability of suitable outdoor learning spaces such as school gardens. Nevertheless, there are initiatives where schools are developing outdoor learning environments with support from municipalities, for instance Vilnius City Municipality projects (Įgyvendinta Vilniaus miesto, 2022). The Lithuanian National Education Agency and the Lithuanian Agency for Informal Education provide guidance on creating these spaces (Gerulaitis et al., 2003). However, these efforts are still in the early stages and are not yet standard practice. The wish is to strengthen the *outdoor* components in soil (health) education.

Process: The process is mainly *instructive,* which may be attributed to the focus on pre-defined topics within the national curriculum. *Emancipatory* processes are not employed and are wished to be strengthened.

Activities: The curriculum mainly focuses on *knowledge-based activities*, with a strong emphasis on knowledge-sharing. When questions and exercises are included, they typically require students to analyse the presented information, seek additional knowledge, or perform similar tasks. *Doing-based* activities are weakly embedded, with only a few practical exercises such as exploring soil fauna (e.g., Baleišis & Zdanevičienė, 2011). Some informal educational activities combine knowing- and doing-based approaches. For instance, some Vilnius City Municipality-supported projects provide interactive soil (health) education (Įgyvendinta Vilniaus miesto, 2022). However, these efforts are limited to a few schools. Lithuania's participation in the GLOBE program provides opportunities for hands-on soil (health) educational activities such as measuring soil fertility (see https://www.globe.gov/web/soil), but schools are not actively involved due to a lack of translated materials and promotion (Vačaitytė, 2020). *Being- based activities* are not typically found in textbooks and are therefore weakly embedded. However, insights from the focus group indicated that one of the teachers' ultimate goals is to encourage pupils to develop a broader understanding of their environment and foster attitudes of care for it. Importantly, while *being-based activities* are only occasionally addressed during soil-related lectures, observations from the Community of Practice in Lithuania reveal that these activities are more deeply explored from the perspective of ethnic culture. The close relationship with nature is a significant part of traditional Lithuanian culture, reflected in folklore, literature, and various forms of folk and contemporary art. The wish is to strengthen doing-based and being-based activities by improving the content of the existing practical activities and by including more such activities, and the focus group indicated strong interest and initiatives from teachers in this direction.

> I lack clear descriptions of exercises. There are no references in the textbooks, for example, please take this and go there.
> - *Geography teacher (from focus group)*

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Paradigm: The national curriculum and textbooks for the secondary education in Lithuania follow a combination of *mechanistic* paradigm with a focus on providing detailed knowledge about soil components, as well as illustrating the interactions of soil (health) with other natural elements, and how human activities affect soil. The wish is to strengthen *ecological paradigm* and shift towards a more balanced approach to soil (health) education that integrates both *mechanical* and *ecological* paradigms.

> …nature is a rhythm. As if you discover the weaving pattern and you understand the connections. My dream would be that these school programmes, they would be written in such a way.
> *- University teacher (from focus group)*

Gaps, challenges & opportunities

Soil (health) is apparently inadequately covered subject in the secondary school curriculum in Lithuania and lacks sufficient depth and detail. Teachers, reflecting in the focus group, feel that the new national curriculum, adopted in 2023 (Bendrosios programos, 2023), has further limited the ecological perspective in educating about soil (health) related concepts and is largely focused on an atomistic view of specific topics on soil (health). This combined with the limited applications of *outdoor, doing-based* learning activities result in an overall lack of awareness about nature including soil (health) amongst students, particularly those in cities.

> If there were some kind of material available made by professionals, a video in one form or another about […] the whole little world of microorganisms that live in soil. […] This would be a great gift for the children of Lithuania.
> *-A teacher (from focus groups)*

To improve soil (health) education, a curriculum revision to increase the emphasis on soil (health), especially from an ecological perspective is needed. Additionally, integration of Mission Soil objectives and SDGs into the curriculum is required to provide students with a broader understanding of the broader significance of soil (health) for human sustenance. While there is a desire to increase outdoor activities, the challenge lies in addressing the formal requirements associated with taking pupils outside the school, which are strongly grounded in safety reasons. There is need to create outdoor learning facilities that are accessible and pose less safety concerns (for instance school gardens). To broaden the collaborations for soil (health) education, it is necessary to cultivate a practice of collaboration. This can be achieved by sharing information about existing opportunities and fostering new partnerships. Additionally, making the teaching of Lithuanian nature and soil (health) mandatory should be considered as a way of bringing nature and soil (health) at a more central position in secondary education system.

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Tertiary education

Vision: To transition towards soil (health) education that follows a more systems-oriented approach and integrates knowing and doing with innovative technologies with a focus on emphasizing soil (health)'s role in ecological and human sustenance.
Needs: To update the textbooks and adopt innovative educational tools that incorporate a more ecological perspective to soil (health), along with creating opportunities for field-based learning.
Opportunities: Courses like Soil Zoology offer examples of how soil (health) topics can be approached from an ecological perspective, providing a model for integrating a systems perspective on soil (health) across other courses and disciplines.

State and wishes of soil (health) education.

Purpose: At the tertiary level soil (health) education in Lithuania is integrated into various disciplines (e.g., biology, geography, agriculture, etc), although with only a weak focus. The specific topics concerning soil (health) are addressed from the perspectives of the specific disciplines and fail to adopt an interdisciplinary approach. Therefore, specific Mission Soil objectives and the SDGs that are embedded within soil (health) education also depends on the disciplinary relevance and context. Overall, the Mission Soil objectives to *reduce soil pollution and enhance restoration* predominantly from chemical applications in agriculture (pesticides and fertilizers), and the goal to *prevent soil erosion* are strongly embedded, while other Mission Soil objectives are nearly absent. In terms of SDGs, the goals of *sustainable consumption and production* is strongly embedded (Aleinikovienė & Staugaitis 2019), along with the SDG *good health and well-being*. Broader social aspects of soil (health) are not addressed, consequently, other SDGs are absent. The wish is to maintain the focus on the goals of *reducing soil pollution and enhancing restoration,* and *preventing erosion.* There is also a wish to approach soil (health) from a perspective that departs from soil currently being treated purely as a resource towards emphasising its value for both ecological and human sustenance. However, the wishes to prioritise specific SDGs in this context is unclear.
In terms of human development, the desk research suggested, the purpose of soil (health) education is predominantly focussed on *knowing,* with some components of *doing*. The interviews, however, presented an insight that tertiary level education integrates all three aspects of the purpose – *knowing, doing and being*. Typically, lectures focus on theoretical knowledge (*knowing*), which is accompanied with laboratory work focussing on developing practical skills (*doing*). The ultimate goal of these is to raise awareness (*being*). The wish is to strengthen the purposes of *doing* and *being*.

Collaboration: Interviews provided an insight that collaborations in soil (health) education at the tertiary level are predominantly *broad*, and frequently involve university teachers across different faculties/disciplines, across different institutes, often engaging with the higher education institutes from other countries, as well as collaborators from multiple sectors besides academia such as farmers, foresters, and industries. Interestingly, students did not recognize the extent of collaborations. The wish is to improve

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communication between the university and the STEAM network for more effective engagement, and to increase collaboration with farmers, specifically those practicing organic farming, to gain insights into their practices.

Space: At tertiary level, soil (health) education employs both *indoor* and *outdoor* learning spaces, however the degree of their usage strongly depends on the discipline. Some courses prioritise indoor spaces such as classrooms and laboratory for soil (health) education, whereas some courses and universities (e.g., Vilnius University) have significant components of outdoor educational activities such as field practices and research expeditions. The wish is to prioritise the outdoor learning spaces for soil (health) education.

Process: There is predominance of *instructive* processes in tertiary level soil (health) education, with varying degrees of *emancipatory processes* depending on the discipline and course. The typical process includes lectures and presentation from educators, which is complemented with several assignments that encourage the students to explore the topics by themselves, ask questions and go deeper into the topics that interest them. Technologies such as GIS and internet has expanded the educational resources beyond textbooks and monographs thus further enabling emancipatory processes. No insights on wishes regarding this aspect could be gained.

> I liked the idea that soil creates life from death. That's something we don't really understand.
> *- High school teacher (from interviews)*

Activities: At the tertiary level, soil (health) education predominantly combines *knowing-based* activities like lectures and readings with *doing-based* activities like laboratory experiments and field trips. For instance, the course Soil Science for Agronomy for students at Vytautas Magnus University includes 20 hours of laboratory work and 20 hours of field practice along with 24 hours of lectures (Vaisvalavičius, 2018). During the field practice students leave for field practice to different regions of the country and engage into observation and documentation of soils, including the aspects related to soil (health). *Being-based activities* are absent. The wish is to introduce innovative technologies such as apps, quizzes and games to support *knowing-based* activities which may allow students to engage more and go deeper into the topics.

Paradigm: In tertiary level soil (health) education, both *mechanistic* and *ecological paradigms* are embedded with their varying degrees of importance depending on the discipline and course. Overall, *mechanistic paradigm* seems to dominate. Teaching materials and course curricula related to soil (health) education focus on mechanistic aspects, such as soil components, characteristics, and typologies, while also addressing factors like climate, human activities, and soil's ecological functions. For instance, human impact on soil composition and geochemistry of fertility, which in turn affects its ecological functions are addressed (Motuzas et al., 2009). Courses such as 'Soil Zoology' explore soil as a living space (Podėnienė, 2021). The wish is to approach soil (health) education from a predominantly *ecological paradigm*.

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Gaps, challenges & opportunities

At tertiary level, soil (health) education in Lithuania lacks modern textbooks. In addition, relatively weaker ecological perspective to soil (health) education in most courses does not allow students to gain a comprehensive understanding of soil (health) and its importance for broader ecosystemic and human systems. The decreasing trend of field practice opportunities, and insufficient collaboration with non-governmental organizations further limit the effectiveness of soil (health) education.

To address these challenges, the educational resources need to be updated with potential incorporation of innovative educational technologies such as apps and games. Teachers need necessary tools, trainings, and support to transition towards wished educational design for soil (health) education.

> The best thing would be to do it [educate students] outside. Botanical reserves and geological reserves are perfect for this, for example in some places there is a very cool thing with river outcrops-
> *- High school teacher (from interviews)*

Vocational educational training (VET)

Vision: To explicitly include soil (health) into the curricula at the VET level.
Needs: To provide teachers with the necessary educational materials on soil (health).
Opportunities: To expand teaching on soil (health) by building on the existing informal interest in soil (health).

State and wishes of soil (health) education.

Purpose: There is a weak focus on soil (health) at the VET level education. Soil topics are specifically embedded into the following professional courses: Agricultural Worker (Žemės ūkio darbuotojo, 2022); Agricultural production business worker (Žemės ūkio gamybos verslo darbuotojo, 2018); and Ornamental Horticulture Worker (Dekoratyvinio apželdinimo darbuotojo, 2022). The curricula, approved by a central agency (Qualification and Vocational Education and Training Development Centre) focus on soil (health) from a utilitarian point of view. For example, the curricula for Agricultural Worker and Ornamental Horticultural Worker both aim to develop a competence for preparing the soil for growing agricultural or ornamental crops, without specifically addressing soil (health) topics. Consequently, none of the Mission Soil objectives were found to be embedded, and the SDG of *responsible consumption and production* is weakly embedded in the VET courses. None of the aspects of human development were embedded within the soil (health) education for VET courses. Nevertheless, informal interest in soil (health) does exist, as evidenced by examples such as a bed of soil-cleaning plants installed at the Marijampolė Centre for Professional Education and the Orangery at Zarasai Professional School, which provides space for research on soil characteristics (Gerulaitis et al., 2003). No insights on the wishes for different aspects of purpose for soil (health) education could be gained.

Collaboration: Desk research did not provide insights on the state or wishes for learning space in soil (health) education at VET level.

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Space: Desk research did not provide insights on the state or wishes for collaborations in soil (health) education.
Process: Desk research did not provide insights on the state or wishes for processes used to facilitate soil (health) education at VET level.
Activities: Desk research did not provide insights on the state or wishes for educational activities used to facilitate soil (health) education at VET level.
Paradigm: Desk research did not provide insights on the state or wishes for paradigms of soil (health) education at VET level.

Gaps, challenges & opportunities

Soil (health) education is largely absent from VET courses, highlighting the need to integrate soil (health) into various VET programs. Due to insufficient information on the current state and specific wishes for soil (health) education, specific gaps and needs could not be identified.

General public

Vision: To create a focus on soil (health) issues and importance of educating broader society beyond farming communities.
Needs: To develop practical soil (health) educational programs tailored to all age groups and professional backgrounds, with a strong emphasis on engaging learners from an early age.
Opportunities: The growing popularity of urban and community gardens in Lithuania offers a learning space for hands-on soil (health) education, engaging diverse communities in practical learning experiences.

State and wishes of soil (health) education.

Purpose: At the most general level, the framework for soil (health) education in Lithuania is set by the Action Plan for the Sustainable Use of Soil, adopted in 2023 by the Ministry of Agriculture (Dirvožemio tvaraus naudojimo veiksmų planas, 2023). The main goal of this plan is to establish long-term actions for the use and protection of soil as a vital national natural resource, including promoting soil (health) education among the general public, and the direct soil users.

Soil (health) awareness outreach topics primarily employ media, primarily focus on agriculture-related topics and are often tied to events or projects related to the EU Green Deal, and sustainable farming. These offers highlighted the EU mission goals of *preventing erosion; conserving soil organic carbon stocks,* and *reducing soil pollution and enhancing restoration* (Juozapavičiūtė, 2012; Žaliasis kursas, 2022; Volungevičius & Veteikis, 2023). The Mission Soil objectives of *stopping soil sealing and increasing urban soil re-use, reducing desertification, reducing the EU's global soil footprint, and improving soil* literacy are weakly embedded, likely since these topics are not considered a priority for Lithuania (Ateities iššūkis, 2015; Trofimišinas, 2019; Abugelis, 2023). The EU's role in reducing soil impacts is only lightly covered, with a focus often on local issues.

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In terms of SDGs, the soil (health) awareness programs focus on the SDGs of *responsible consumption and production, and sustainable cities and communities*. The Action Plan for the Sustainable Use of Soil highlights how intensive farming, improper fertilization, and heavy machinery affect soil (health) (Dirvožemio tvaraus naudojimo veiksmų planas, 2023). Media coverage, especially in farming publications, emphasizes soil (health) in the context of sustainable agriculture (Lietuvos dirvožemio studija, 2023; Žemės ūkis gerokai prisidirbo?, 2019). The SDGs of *zero hunger* and *good health and well-being* are weakly embedded (Ar šiandien, 2017), while other broader SDGs that include goals such as *reducing inequalities, clean water and sanitation* etc. are absent.

No insights could be gained into the wishes for embedding specific Mission Soil objectives or SDGs.

> Ideally, it [soil education] should be outdoors. It depends on the format, if it is an experiment, I would say it should be outdoor, there should be some kind of places where you can observe the process.
> *– NGO representative (from interviews)*

In terms of human development, soil (health) educational resources for the general public tend to incorporate *knowing* and *doing*. Sources targeting farmers specifically focus on promoting sustainable farming practices. Actionable guidance for general public is often limited and target amateur gardeners who receive practical advice on improving soil quality, for instance via practicing crop rotation (Kas yra sėjomaina, 2021). The purpose of *being* is not embedded. No insights into the wishes for the purpose of soil (health) education on this aspect could be gained.

Collaboration: The soil (health) related education for the general public is predominantly offered through *narrow-broad* collaborations which commonly includes scientists and farmers. The Action Plan for the Sustainable Use of Soil declares goals of inter-institutional collaboration nationally and internationally, such as between state institutions and companies, between Lithuanian and international organizations active in promotion of soil (health) (Dirvožemio tvaraus naudojimo veiksmų planas, 2023). *Narrow* and *broad* collaborations are weakly embedded. The wish is to make the collaborations *broad* and engage public authorities – ministries, municipalities and city administrations as well as schools and educational NGOs.

Space: Learning space for soil (health) education for general public is predominantly *indoors* and is usually in the form of newsfeed. No information on outdoor activities focused on soil (health) for the general public could be found. The wish is to adopt a combination of *indoor* and *outdoor* education with an emphasis on *outdoor*s.

Process: Soil (health) awareness offers for general public are predominately facilitated through *instructive* processes in the form of information. For farmers, there are some examples of emancipatory processes concerning soil (health) education, for instance discussion groups in conferences; howeverthese processes are weakly embedded. No examples of emancipatory processes for general public could be identified. No insights on the wishes for educational processes could be gained.

Activities: In soil (health) awareness offers for general public, *knowing-based* activities dominate. No examples of *doing-* or *being-based* activities were identified. The wish is to

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facilitate soil (health) education through a combination of *knowing*- and *doing-based* activities which are easy-to-understand, target all ages, and begin early on.

Paradigm: Soil (health) awareness offers for general public predominantly adopt an *ecological* paradigm with discussions focusing on how soil (health) affects various aspects of life, and the how human activities affect soil (health). The *Mechanistic paradigm* is weakly embedded (e.g., the focus on educating about soil components as outlined in the Action Plan for the Sustainable Use of Soil (Dirvožemio tvaraus naudojimo veiksmų planas, 2023). The wish is to continue approaching soil (health) education with an *ecological paradigm*.

> You have to be a very big expert to be able to determine the type [of soil] after digging it up.
> – *University lecturer (from interviews)*

Gaps, challenges & opportunities

There is a lack of awareness about soil (health) among the general public, as well as a shortage of educational offers on the topic. However, direct users of soil, such as farmers, are better informed and engaged through conferences, information, and discussions in specialized media.

> I would imagine that education should take place from an early age, and that it should take place through practice.
> – *NGO representative (from interviews)*

Urban and community gardens, which are becoming increasingly popular in Lithuania, could potentially serve as valuable spaces for soil (health) education. However, their role in this regard is not yet fully established. To foster sustainable land management and environmental stewardship in Lithuania, raising public awareness of soil (health) and promoting education in this area is crucial.

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A.8. Netherlands

The soil (health) education in the Netherlands largely centers on topics related to soil biodiversity, contamination and restoration and climate change. Soil and water management education is intertwined and predominant across all educational levels reflecting the country's policy emphasis on land-water management nexus and significance of agriculture sector. The weak representation of how soil (health) is important for societal SDGs, and the general lack of a systems approach to soil (health) education indicate an oversight in recognizing the importance of soil (health) within sustainability education. Additionally, the soil (health) education tends to prioritize knowledge acquisition, including in some cases hands-on approaches to learning, while enabling exploration of personal connection with soil is largely missing. During the discussions in the CoP, a wish emerged to focus on fostering developing relation with soil (*being)* at the primary educational level with gradually building up the knowledge and skills as students advance towards secondary with more deeper specialized knowledge and problem solving at tertiary level.
To achieve the wished state of soil (health) education, which focuses on educating on the value of soil (health) and its broader ecological and human connections, a transition towards more experiential and emancipatory teaching methods is needed. Additionally, identifying and facilitating the optimal balance of transdisciplinary and broader collaborations for different educational levels and programs would allow for a creating a more holistic, real world understanding. This calls for adapting curriculum with more specific focus on soil (health) and enabling teachers via specialized trainings and allocating resources to facilitate such educational approaches.
It is also crucial to identify approaches and introduce the topics that interests the learners (learner-centric). Specifically for the general public and primary students, few emerging approaches that raises curiosity (movies, games, and hands-on activities) are very valuable. Such approaches could be further stimulated, and considered also in other educational levels. In case of primary and secondary education, existing extra-curricular environmental education programs offer innovative examples of the wished experiential and emancipatory educational approach. Expanding such programs and collaborating with these external environmental organizations provide an opportunity to work towards closing the gaps identified in this analyses, while educational system may gradually be reoriented towards the 'wished' state.

Methodological and Contextual Considerations

The Netherlands has a decentralized education system that provides schools significant autonomy in curriculum development. Ministry of Education, Culture, and Science sets legal requirements and general educational goals, however, there is no standard national curriculum. This made obtaining specific course modules on soil (health) from schools (primary and secondary) infeasible for desk research. Due to limited access to school syllabi, the desk-research could not provide in-depth knowledge on how soil (health) topics are embedded within formal curricula. Therefore, analysis for primary and secondary levels predominantly relies on the desk-research of the courses on soil (health) related education

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offered by environmental educational organizations and focus group discussions and interviews conducted within this project.

Primary education

Vision: To educate on the value of soil (health) and its broader ecological, sustainability and human connections.
Needs: A shift towards more experiential and emancipatory teaching methods is required. This necessitates adapting the curriculum, providing teacher training and resources.
Opportunity: Existing extracurricular environmental education programs, connecting kids to nature and raising their curiosity for soil, serve as some examples of the wished approaches. Those programs can offer inspiration for reconsidering formal curricula.

State and wishes of soil (health) education

Purpose: In the Netherlands, the soil (health) education in primary education mainly focuses on soil biodiversity *(improving soil structure to enhance biodiversity),* and the importance of soil for water availability (*clean water, sanitation),* and *life on land*. For example the course 'Onder het maaiveld (IVN, n.d.a) for primary school students as well as teachers specifically asks the question "Why is healthy soil so important and who lives in the soil?". The connections of soil (health) with SDGs such as *zero hunger, affordable and clean energy, industry, innovation and infrastructure, sustainable cities and communities, and climate action* are weakly embedded, and those with broader societal challenges such as n*o poverty, good health and well-being, responsible consumption and production etc.* are not embedded. There is a strong wish to embed broader concepts (which includes *stopping soil sealing, increasing reuse of urban soils, reducing pollution, enhancing restoration, preventing erosion, and improving soil structure for biodiversity)* and connections of soil (health) with broader societal goals like *good health, wellbeing, and sustainable communities* in educational programs.

In terms of human development, most project-based offers for primary education is offered by environmental education organisations. Purpose of such extra-curriculum offers is to facilitate hands-on activities and field observations (*doing)*, with components of helping students develop their connection with nature and soil (*being*). For instance, certain activities encourages students to engage with the soil by prompting them to reflect on its appearance, texture, and scent (e.g. Geoweek excursions by Witteveen+Bos, 2023). Interview with expert indicated these are not the mainstream and in the mainstream school curriculum, the primary purpose is on acquiring knowledge (*knowing*). The wish is that education should facilitate and foster a personal connection with nature and soil, and understand the link between soil and food.

> If you are just fascinated by the world of the soil and experiencing what soil can do in multiple ways for us as humans - as a child, that's the fundament, the basis. If you have this relation with soil, perhaps the rest follows.
> *– A civil society representative (from interviews).*

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Collaboration: Soil (health) education in primary schools in Netherlands involves several external environmental educational organizations (e.g. IVN natuureducatie), still it is predominantly *Narrow*. *Broad* collaboration is limited. Interactions often cantered around students and teachers. Broadening collaborations to include diverse stakeholders, emerged as a strong wish.

Learning space: While several programs emphasize *outdoor* education, experiential learning in natural settings (gardens, forests, schoolyards), where soil (health) is explored through hands-on activities and observation, is not the mainstream. *Indoor* classroom learning appears to play a more dominant role in soil (health) education in primary education. The wish is to make the soil (health) education more *outdoor* and experiential.

Process: The process is mainly *instructive*, however, there are several project-based courses offered by environmental educational organizations where an *emancipatory* approach is strongly embedded and empowers students to learn about soil and develop a sense of care for soil. The wish is to transition towards education process which is more *emancipatory*.

Activities: In the primary education, the mainstream education appears to adopt predominantly *Knowing-based* activities, whereas, the courses offered by external environment educational organizations mainly follow *doing-based* activities. *Being-based* activities are generally absent. The wish is to facilitate soil (health) education through a balance of *knowing-, doing-* and *being-based activities* where, acquiring information, hand on activities and developing a personal relation and care for soil complement and reinforce each other.

Paradigm: Greater emphasis is on *mechanistic* paradigm; however the wish is to follow the *ecological* paradigm and educate about soil's multifunctionality and its role within the broader socio-ecological system.

Gaps, challenges & opportunities: Primary school may be considered an ideal time to introduce soil (health) education and facilitate students to explore their connection to soil (Brevik, E. C., et al., 2022). Currently, there is an apparent lack of formal emphasis on soil (health) topics in primary school, and soil related topics are most likely incorporated within different subjects (geography, biology etc.). Currently, soil (health) education seems to be focused on soil biodiversity, which is important, yet there is a need to incorporate more specific soil (health) topics and illustrate their connections to broader ecosystems and sustainability.

To address these gaps, a significant challenge lies in designing approaches that are engaging and simple enough for the age group 4-12 years. Effective approaches could involve hands-on, inquiry-driven learning methods that connect soil to students' everyday lives. Such an approach would alongside facilitate the wished shift towards experiential and *emancipatory* educational models, and would potentially go hand-in-hand with expanding *collaborations* for soil (health) education. However, implementing such changes calls for resources (Margenot, A.J., et al., 2016) and providing more specialised teacher training which currently does not prepare them for the mentioned (wished) educational approaches.

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> … if you bring all the big questions, it becomes really important to be careful on how we introduce a subject and how we build on the relation instead of just putting so much pressure on children.
> - *A civil society representative (from interviews).*

Existing extra-curricula programs offered by environmental education organizations (e.g. IVN natuureducatie) and sustainability-oriented school networks (e.g. ecoschools) promoting innovative experiential approaches, presents an opportunity. Such approaches, raising the appreciation of kids for the value of soil, by bringing them in nature or by showing inspiring videos, can be further embedded into formal programs, in order to foster a holistic understanding of soil (health), through *doing* and *being* approaches.
However, it is also crucial that introduction of new topics and approaches do not overwhelm the students, rather just introduce them stepwise while building upon the curiosity of the learners.

Secondary education

Vision: To foster personal connections with soil and create understanding of soil (health) within broader socio-ecological sustainability via balanced approaches of instructive-emancipatory, knowing-doing-being based activities and under indoor and outdoor learning spaces.
Needs: To reorient educational policies and curriculum with increased emphasis on soil (health) topics and facilitate more emancipatory forms of learning through investments in resources and specialized teacher training.
Opportunities: To expand existing valuable approaches where students can directly engage (such as citizen science projects) and incorporate approaches that encourage to address real-world challenges within formal curricula.

State and wishes of soil (health) education.

Purpose: The soil (health) education in secondary schools focuses on certain aspects like *preventing erosion, conserving soil organic carbon stocks, sustainable cities and communities, climate action, sustainable production and consumption, and life on land.* However, certain topics outlined in the EU Mission Soil, such as, *improving soil structure to enhance biodiversity, re-use of urban soils*, *and reducing the EU global footprint on soils;* and within context of sustainable development goals such as *clean water and sanitation are weakly represented*. Moreover, connections between soil and broader sustainability goals such as *zero hunger* and broader socioeconomic goals (e.g. *no poverty*) are missing. The wish is to increase attention to these specific topics, as well as others that are weakly represented or missing entirely. These includes enhancing *soil literacy in society* and establishing clear connections with broader sustainable development goals, notably *good health and wellbeing, quality education, climate action, life on land, and peace, justice, and strong institutions*.

In terms of human development, soil (health) education has the main purpose of transferring and acquiring knowledge about soil (health) (*Knowing*), with some emphasis on experiential learning (*Doing).* Additionally, there is a lack of focus on fostering personal

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connections with soil and developing a sense of care and responsibility towards it (*Being*). The wish is to shift towards a more balanced approach to soil (health) education that incorporates all three dimensions to ensure a comprehensive understanding and appreciation of soil (health) and its importance for sustainability.

Collaboration: Soil (health) education in secondary schools in the Netherlands involves several external environmental educational organizations, yet collaboration remains predominantly *narrow*. While occasional involvement of external partners such as scientists (e.g. via citizen science projects) occurs, *broader collaboration* is generally weakly embedded or missing. The desire is to achieve *broad collaboration* in soil (health) education, allowing diverse stakeholders to participate and broaden the scope of learning, and benefiting students by allowing for diverse perspectives and critical thinking under multidisciplinary settings, often closer to real-world challenges.

Learning space: Soil (health) education in secondary schools occurs primarily *indoor,* in the classroom setting. *Outdoor* forms of education are rarely integrated into formal curricula. However, *outdoor education* is strongly embedded as extracurricular or project-based courses offered by environmental education organizations. There is a strong wish is to expand the *outdoor* component in a formal school curricula.

Process: The process is mainly *instructive.* Although there are few examples of *emancipatory* forms of education, where students actively shape their learning process (e.g. Buitenles: Hoe klimaatproof is jullie schoolplein? By IVN (n.d.b), the curriculum is mainly dominated by traditional *instructive* approaches. This could be attributed to the way courses are designed which predominantly rely on a structured program and pre-defined learning objectives. The wish is to have a balanced approach to soil (health) education at the secondary level, combining i*nstructional* methods with *emancipatory* processes.

Activities: Secondary education programs adopt an approach that especially includes *doing-based* activities, where students can explore soils during a project, field excursion or practical assignment (e.g. citizen science projects-Levende Bodem and SMAP (GLOBE Nederland 2023 & 2024)). *Knowing-based* activities are primarily assumed to be implicit within the subjects such as environmental science, geography and biology. '*Being-based*' activities are generally absent. There are however some exceptions. The wish is to balance *knowing, doing, and being-based* activities in soil (health) education, reinforcing each other. Prioritizing *being-based* activities is desired due to their scarcity at the secondary level and their potential to foster a strong connection between teenagers and soil.

Paradigm: Apart from a focus on a mechanistic paradigm, soil (health) education in secondary education embeds an ecological paradigm.. With the increase of new programs, such as citizen science projects, students can learn and contribute to the research thus gain an opportunity to learn and understand important processes in soil and how those sit within broader ecosystem functions. An example is Levende Bodem (english translation-living soil) (GLOBE

> Ecological considerations are not only relational. They can also be viewed objectively or in a rational way.
> *-A secondary teacher (from interviews).*

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Nederland, n.d.) project where students gain insights int soil (health) by learning and taking measurements of soil respiration, soil organic matter, soil hydrology and how these are important for climate regulation, food production and supporting life of the earth.

Gaps, challenges & opportunities: At the secondary level, soil (health) is often not explicitly emphasized, Rather, it is mostly integrated into other subjects. This integration may lead to brief mentions of soil-related aspects, for instance, erosion in geography courses. This lack of explicit focus on soil (health) very likely results in gaps in students' understanding of its importance and relevance. These gaps seem to partly stem from a lack of recognition of soil's connections to the Sustainable Development Goals (SDGs) in education guidelines, such as UNESCO's Education for Sustainable Development (ESD) roadmap (UNESCO, 2020). Furthermore, there is a need to shift teaching processes towards more *emancipatory* approaches.

> Because students are accustomed to instructional methods now, if they were to have a fully emancipatory day, they wouldn't know what to do.
> *-A secondary school teacher (from interviews).*

To address these gaps, there's a need to reorient the educational policies and curriculum with increased emphasis on soil (health) topics and create conditions where such more emancipatory forms of learning can be facilitated, by investing resources and specialized teacher training. Increasing number of citizen science projects offer opportunities where secondary level students know, and do, and often develop a sense of shared ownership of the project outcomes(be).

Tertiary education

Vision: To create deeper understanding of the importance of soil and its connections with broader SDGs, soil EU Mission Soils and addressing pressing challenges alongside fostering a culture of care and inspiring action towards soil stewardship.
Needs: To strengthen the representation of soil (health) and to emphasize its role from both ecosystem and socio-economic system perspectives.
Opportunities: There are opportunities to increase collaboration and balance instructional methods with more emancipatory processes within existing settings.

State and wishes of soil (health) education.

Purpose: The focus of the tertiary level soil (health) education in the Netherlands primarily revolves around *reducing soil pollution and enhancing restoration*, with courses addressing topics like nitrogen deposition, heavy metal pollution, and soil restoration (e.g. Future Planet Studies (Universiteit van Amsterdam., n.d.) and Soil pollution and soil protection (Wageningen University., n.d.d). The focus is relatively weak on *conserving soil organic carbon stocks* – despite its prominence in scientific research, especially for its debated role in managing and mitigating climate change. Similarly, there is a weak focus on *increasing soil literacy.* However, since the launch of the EU Mission Soil, efforts to increase soil literacy have begun at the university level with initiatives like living labs and lighthouses, especially at the doctoral level (Lazeroms, 2021), and is strongly corroborated

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by the findings of the focus groups and interviewees sharing their insights on the higher education.

There is also relatively weak focus on how soil (health) is connected to SDGs such as *climate action and industry, innovation, and infrastructure*. While several courses have incorporated climate change processes and their impact on the natural environment, soil (health) is only weakly embedded in most courses (mostly in higher vocational education (HBOs)) particularly within mainstream topics on agriculture and horticulture. (e.g., Masters course in Earth, Life and Climate (Utrecht University., n.d.) and Biogeochemical Cycles and Climate Change Mitigation (Wageningen University., n.d.c.) and Horticulture & Business Management (HAS Green Academy, n.d.a.).

The specific focus on connections of soil (health) with broader SDGs, such as n*o poverty, good health and well-being, quality education, gender equality, affordable and clean energy, decent work and economic growth, reduced inequalities, sustainable cities and communities, responsible consumption and production, life below water, life on land, peace, justice, and strong institutions, and partnerships for the goals* are found to be missing. This may be attributed to the fact that soils are mainly studied within the context of crop production, biophysical interactions, to a degree in relation to specific ecosystem services. The complex relationships between soil and the wider food system, society, economics, and inequalities are typically only addressed in advanced research. The wish for soil (health) education is to strengthen certain key aspects —*conserving soil organic carbon stocks, reducing soil pollution and enhancing restoration*, and improving soil structure to enhance *soil biodiversity*.

In terms of human development, the primary focus particularly in university courses seems to be on gaining knowledge (*knowing*) with relatively less focus on experiential (*doing*), while understanding personal relationships (*being*) is only present in few courses. In higher vocational education (HBO), however, there seems to be a more balanced purpose of both *knowing* and *doing*. The wish is to achieve a balance across all three aspects—*knowing, doing*, and *being. Being* emerged as a crucial component of the purpose of soil (health) education to evoke caring sentiments. Given its current poor representation, suggestions are to strengthen it while maintaining *knowing* and *doing* aspects.

> Learning and teaching about regenerative agriculture cannot be done without the Being. The head, heart, and hands need to be all present.
> *- A university lecturer (from interviews)*

Collaboration: Tertiary level soil (health) education was found to have predominantly *narrow* collaboration, primarily involving students and teachers, with occasional engagement of external partners during field trips or internships. In contrast, soil education in Higher Professional Education (HBOs) demonstrates a predominance of *narrow-broad* collaboration, and involving several stakeholders such as companies, clients, farmers, peers, and teachers (e.g. Milieukunde at HAS Green Academy, n.d.b.).

Learning space: In tertiary soil (health) education, *outdoor* learning opportunities are weakly embedded, despite some courses including field excursions and studies in farmer fields

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and natural landscapes (Hartemink et al., 2021). Although most programs incorporate some *outdoor* components, there is a need for evaluation to enhance their effectiveness in achieving learning outcomes.

Process: At the tertiary level, soil (health) education primarily relies on *instructive* processes, characterized by structured curriculum and teacher-led knowledge transfer, particularly in universities. *Emancipatory processes*, although weakly embedded, are not entirely absent. While most courses emphasize expert-led instruction, some HBO courses and certain university projects offer opportunities for more *emancipatory* learning experiences. Examples include Bushcraft and nature skills teachers training course (Wageningen Pre-University, n.d.). The wish is to have a balanced approach to soil (health) education at the secondary level, combining i*nstructional* methods with *emancipatory* processes.

Activities: At the tertiary level of education in the Netherlands, soil (health) education primarily emphasizes *knowing-based* activities, focusing on the acquisition of information through lectures, assignments, and projects. While most university courses incorporate some *doing-based* activities, such as laboratory and field experiments, they are relatively minor components compared to *knowing-based* activities. In contrast, HBO courses place a higher emphasis on *doing-based* activities, with greater components of hands-on activities and emphasis on learning to apply knowledge and skills in real-world contexts. However, *being-based* activities, where knowledge and skills may be merged with personal connection and values related to soil (health), are largely missing from both university and HBO courses. The wish is to balance *knowing, doing, and being-based* activities in soil (health) education, reinforcing each other. Prioritizing *being-based* activities is desired due to their scarcity at the secondary level and their potential to foster a strong connection between teenagers and soil.

Paradigm: The *Ecological* paradigm could be more embedded in soil (health) education, particularly in university courses where compartmentalized disciplines dominate. Although several courses are becoming more multidisciplinary (e.g. Biogeochemical Cycles and Climate Change Mitigation (Wageningen University, n.d.b) and The Soil Carbon Dilemma (Wageningen University, n.d.d), they are still less trans-disciplinary and broader systems view of soil is largely absent.

Gaps, challenges & opportunities:

In the Netherlands, there is a wide range of tertiary level courses that offer soil-related education. However, , there is a weak representation of a systems-oriented approach. Main focus remains on mechanisms of soil processes and functions and occasionally on connections to broader ecological and socio-economic systems.

> I think many aspects of soil (health) are also very new to scientists. So, it is something that lends itself well into being more emancipatory, providing a space where students can ask questions to the lecturer, and where lectures can ask questions to students.
> *-A university lecturer (from interviews).*

While strengthening the representation of SDGs and Mission Soil objectives in the curriculum

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could help close this gap, this also calls for increasing trans-disciplinarity (e.g. soil science, economics, social sciences, etc), and broadening the collaborations to include diverse stakeholders. This also will increase the complexity of teaching and learning, requiring interdisciplinary and sectoral knowledge. This challenge can be addressed by identifying common goals and interests across collaborators. Furthermore, to achieve the desired more holistic state of the soil (health) education, there's a need for more *emancipatory* and experiential learning of soil within its natural environment and real-world conditions, (e.g. farms, forests, eroded landscapes,) which allows the students to explore and express their relationship with soil in addition to developing the knowledge and application oriented skills.

Vocational educational training (VET)

Vision: To broaden soil (health) education that prepares professionals to include soil (health) and its interconnections to broader socio-ecological sustainability challanges.
Needs: There's a need to bridg the gap between soil education and broader societal goals, by revising of curricula to ensure relevance and specificity.
Opportunities: VET soil education presents opportunities to balance indoor and outdoor learning, enhance collaboration with diverse stakeholders, and incorporate a balanced approach encompassing knowing, doing, and being-based activities to foster a holistic understanding of soil (health) and its implications for society and the environment.

State and wishes of soil (health) education

Purpose: Agriculture is an important sector in the Netherlands. Therefore, several VET courses focus on the role of healthy soil in food production. Therefore, there is a major focus on *zero hunger in addition to improving soil structure to enhance soil biodiversity. For instance, the* minor Vitale Bodem (Kies op maat, n.d.) addresses the concern on " production of sufficient food" and the "growing population," also making reference to *responsible consumption and production*. In addition, several courses offer the education on soil in close connection to water management (*clean water and sanitation)* reflecting the emphasis on the nexus between soil and water, and their importance to agriculture. Both resources, land and water are under immense pressure and pose an important challenge for the sustainable development of the Netherlands. For example, course Vakbekwaam hovenier (English-Skilled gardener) course (KIES MBO., n.d.b) specifically mentions that students "will learn how to improve soil and also to find a balance between soil and water." Courses also address soil (health)'s connections to the climate change, specifically *climate action, sustainable cities and communities, and conserving soil carbon stocks,* as well as on r*educing soil pollution and enhance restoration.* Certain aspects considered important for the soil (health) as outlined under EU Mission Soil, are found to be missing. These include *reducing desertification*, *stopping soil sealing and increase re-use of urban soils and* preventing *erosion.* Also, soil (health) connections to broader societal goals (e.g. *improving soil literacy in society, no poverty, good health and well-being, quality education, life below water,* etc, were also missing indicating indicating a lack of recognition of soil's links to broader economic and societal well-being.

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The wish is to include and emphasise on *improving soil literacy in society,* with the need to broaden the concept of soil literacy that goes beyond the information on soil (e.g. soil types, their importance for ecosystem functions and SDGs, etc) and includes interconnections across Mission Soil objectives, SDGs and our future. Likewise, embedding the connections of soil (health) with broader sustainability goals (specifically, *sustainable cities, communities, responsible consumption, production, peace, justice and strong institutions and Life on land*) is also wished for.

In terms of human development, predominant focus of soil (health) education at the VET level is on "*knowing*"' and "*doing*". The VET courses are aimed towards hands-on professions like gardening and landscape management, and therefore prioritise on developing practical and applied skills. The focus on relational aspect (*being*) is missing. There is a clear wish for a balanced approach to VET courses with a soil (health) component, encompassing *knowing, doing*, and *being*.

> It would be good to give some more attention to the social emotional component, but in a way that is attractive to them [students].
> *– A VET representative (from interviews).*

Collaboration: Collaborations in Soil (health) education in VET in Netherlands seems to be predominantly *narrow, and* frequently *narrow-broad* as students and teachers often engage with external partners and stakeholders, mainly via student internships or fieldwork. For example, course Onderzoeker Leefomgeving (Researcher in the living environment) (Kies MBO, n.d.a). Broadening collaborations to include diverse stakeholders, emerged as a strong wish.

Learning space: Most soil education VET programs are designed to take place both *indoors* and *outdoors*. Most courses include indoors learning in classrooms and laboratories as well as outdoor learning during field excursions and the study of soil and landscape processes in farmer fields, as well as natural or urban landscapes. However, the balance is relatively stronger towards the *indoor*. The wish is to achieve a more balance across *indoor* and *outdoor* learning.

Process: In MBO courses, *emancipatory* processes are more prevalent and complement the *instructive* processes. Courses tend to facilitate problem-solving and requires students to apply acquired knowledge in professional settings. For example, students learn how to conduct consultations and work for clients (e.g. Skilled gardener (KIES MBO., n.d.b.). A balanced approach is wished.

Activities: In the VET education, the education is mainly facilitated by *doing-based* activities. Common activities include soil sampling and analysis, mapping and designing (e.g. designing green spaces), finding adaptation measures to climate change impact e.g. drought, sea level rise) as well as adhering to regulations (e.g., Researcher in the living environment at KIES and Garden, Park & Landscape at Vonknh). *Knowing-based* activities, although less prominent, prepare the students for *doing-based* activities. *Being-based* activities are absent. The wish is to facilitate soil (health) education through a balance of *knowing-, doing-* and *being-based activities* where, acquiring information, hand on

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activities and developing a personal relation and care for soil complement and reinforce each other.

Paradigm: Greater emphasis is on *mechanistic* paradigm. In most VET programs, soil (health) education envisions soil as made up of components, and their objective it to apply this information for instance to make farming more productive. The wish is to follow a balance of both *mechanical* and *ecological* paradigms.

> The ecological approach is valid. The challenge consists in overcoming scepticism from other teachers.
> *–A VET representative (from interviews).*

Gaps, challenges & opportunities

While soil (health) education is typically incorporated within soil-related modules, the topics often remain broad, lacking specificity on soil (health). This disconnect between soil (health) and broader socioeconomic sustainability goals represents a significant gap that requires attention. To address this, curricula need revising to ensure relevance to course objectives and students' aspirations. Given the practical nature of VET, it's crucial to highlight how soil (health) is integral to the economy and social well-being. Incorporating activities like research projects, business assignments, and practical coaching can facilitate embedding these connections within VET programs (Kupper et al., 2012). Moreover, embracing an ecological paradigm presents an opportunity to view soil holistically, encompassing its social, economic as well as cultural dimensions.

General public

Vision: To facilitate soil (health) literacy that enables people (general public) to develop interest for and identify the value of soil in their everyday lives and to create a culture of care.
Needs: To adopt approaches that can present the importance of soil processes and functions in simplified and engaging ways, and that raise the curiosity of diverse audiences.
Opportunities: Soil (health) awareness programs for the general public often involves unconventional teaching forms and grassroots organizations, presenting an opportunity to engage diverse stakeholders and utilize engaging approaches like games, movies, and arts to raise awareness about soil (health).

State and wishes of soil (health) education

Purpose: Soil (health) education initiatives for the general public in the Netherlands align closely with the EU mission goal of *enhancing soil literacy in society*. These initiatives commonly utilize educational tools such as documentaries (e.g. Planet soil, 2023) and citizen science projects (ECHO, 2023; Bin2Bean, n.d.), EU-supported programs like lighthouses and living labs, online courses (e.g. MOOC Soil4Life (Wageningen University & Research, n.d.a) and offers from several environmental organisations (e.g. regeneratieve-landbouw (Foodhub.nl, n.d.). These offers predominantly focus on *improving soil structure to enhance soil biodiversity*, *zero hunger, climate action, reducing soil pollution and enhance restoration etc.* Topics including r*educing desertification* and *responsible*

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consumption and production are weakly embedded in these initiatives, but these are wished to be emphasised.

In terms of human development, the focus is on *knowing* and *doing*, however, there's weak but growing trend towards art-based representations of soil (e.g. art installations, soil tasting) which encourages exploration of personal connection to soil (*being*). The wish is to have main emphasis on *Being*.

> If you feel yourself more connected to nature and to soil, you're also more motivated to make a change.... I think it's the start for actually acquiring knowledge and to act accordingly.
> *- A civil society representative (from interviews).*

Collaboration: Soil (health) awareness offers for general public is predominantly n*arrow-Broad and broad* due to the fact that the programs designed for general public often takes unconventional teaching forms such as games, movies, arts etc and often involves grassroot organisations. For instance, in the course Bodemleven (English-Soils Life) (Platform DIS, n.d.), thinkers and doers (artists, scientists, farmers, chefs etc) come together to study and research regenerative agriculture. *Broad* and *narrow-broad* are also the wished forms of collaboration.

Learning space: While most citizen science, living labs and pilot projects aiming to educate citizen about soil (health) are *outdoors*, the education offers have predominance of modes like documentary films online courses (MOOC), newsletters etc which can be categorized as *indoors*. The wish is to make the soil (health) education more *outdoor* and experiential.

Process: Most soil (health) awareness programs for general public are facilitated through *instructive* processes (e.g., citizen science projects) and one-sided transmission of information by facilitators, often scientists or academics (e.g., MOOC courses, workshops). However, initiatives are beginning to adopt an *emancipatory* approach to address socioeconomic and environmental issues, with strong component of soil. For example, nature-inclusive construction, circular economy, food transition, and water-soil connections through pilot projects e.g. on Ownership and land use (Durzammdoor, n.d.). The wish is to transition towards education process which is more balanced wish both *instructive* and *emancipatory* processes.

Activities: *Knowing-based* activities are predominant via learning through MOOC, documentaries, soil museums, and outreach activities. Followed by *doing-based* activities, e.g. via participating in citizen science projects. *Being-based* activities are generally absent. The wish is to facilitate soil (health) education through a balance of *knowing-, doing-* and *being-based activities*.

Paradigm: The desk research indicates greater emphasis is on *the ecological* paradigm which apparently stems from the fact that the focus in this target group is to avoid information on processes that create, define and make the soil function, but rather how soil is related to overall environment and why it is important. However, the interviews and focus groups reveal that there is greater tendency to have *mechanistic* paradigm. The wish is to follow *ecological* paradigm.

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Gaps, challenges & opportunities

There are two key challenges to soil (health) education for the general public.. First, how to effectively present complex scientific concepts in a simplified manner without alienating learners; and second, how to attract the general public considering soil's perceived lack of urgency.

To address these challenges, adopting approaches which are engaging and raises curiosity about soil are needed. This can involve targeted campaigns to raise awareness on value if soil and the challenges they face in an engaging and thought provoking manner. For instance, a combination of visual arts and stories that everyone can connect to, for example the movie Planet soil (2003) which successfully reached millions of people. Such approaches in combination with other activities where people can engage on relatable topics or spaces (for instance local public spaces or community gardens etc.) will attract the public. Experiential approaches (e.g. soil tasting), and direct engagement in creating information on soil (citizen science projects) would bring people closer to the soil and encourage them to help cultivate the relationship of care. Such approaches would benefit from outdoor activities, and broadening collaborations would be valuable as identified in this analysis. However, such changes face challenges due to resource limitations and the need to strike a balance between indoor and outdoor learning.

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A.9. Poland

The education system in Poland currently lacks explicit focus on soil (health). While the policies seem to have an emphasis on addressing several of the Mission Soil objectives and sustainable development, as well as on disseminating environmental education, the connection across soil (health) and education is weak. There is a strong wish to strengthen a holistic approach to soil (health) literacy at all educational levels in ways that are more engaging and emancipatory.

> There is no system of communication between education system- primary, secondary and higher education. There is no synergy between them and it is difficult to implement it somehow. There is no systemic mechanism that would allow for the penetration of these (soil (health) related) contents from higher education to more basic (primary and secondary) education.
> *-A university teacher (from focus group)*

This calls for revising the existing curricula to specifically incorporate soil (health) topics. Currently there is insufficient cooperation across educational levels, particularly between schools and universities, but also across disciplines. The higher education needs to be encouraged to contribute towards soil (health) initiatives for other educational levels and general public. In addition, there is a need to create opportunities for collaborations between educational system (schools and universities), organizations offering environmental education, policymakers (e.g. local municipalities) and other stakeholders (e.g. farmers). Expanding existing environmental education programs and collaborating with relevant organizations can help bridge gaps in soil (health) education.. Additionally, developing and implementing learner-centric approaches, engaging learners through movies, games, and hands-on activities will help generating interest, particularly among the general public and school (especially primary level) students.

> The challenge is the teacher's attitude, a lot depends on it.
> *-A university teacher (from focus group)*

Primary education

Vision: To create a clear focus on holistic soil (health) education within the context of SDGs and on facilitating knowing, doing and being-based awareness of soil.
Needs: To reorient the curriculum and create opportunities of more outdoor, experiential and emancipatory approaches via expanding resources to teachers and accommodating needs and concerns of students with diverse abilities.
Opportunities: Teacher's freedom in applying educational approaches offers a potential to advance towards the 'wished' approaches conducing innovation in teaching methods.

State and wishes of soil (health) education

Purpose: Soil (health) education in primary schools in Poland generally does not address specific Mission Soil objectives. However, there is some knowledge passed on about soil contamination (*soil pollution and enhance restoration*), *preventing erosion* and *reducing desertification*. While SDGs are present in the curricula, their connections to soil (health) is weak and is made to only a few SDGs, specifically, *responsible consumption and*

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production, and *zero hunger*. For instance, Geography classes (grades IV-VIII) incorporate soil (health) by illustrating real-world examples of its importance, such as addressing food insecurity in Ethiopia and understanding the impact of climate on farming in the Sahel zone (MEN and ORE). There is a strong and urgently expressed wish to raise awareness about *stopping soil sealing and increasing re-use of urban soils,* and to address soil (health) in context of all the SDGs.

In terms of human development, the purpose of soil (health) education is focussed primarily on *Knowing* with minor components of *doing*. For instance, in geography classes (grades IV-VIII), students learn about types of soil in Poland, their distribution and agricultural suitability" (MEN and ORE). *Being* is absent. *Doing* and *being* are wished to be embedded.

Collaboration: Soil (health) education in primary schools in Poland is predominantly *narrow,* and in some instances *narrow-broad.* For example, in the subject "Nature" (Grade IV), students engage in activities to learn about nature. However, these activities are often limited and require support from school management, local authorities, and the community. The wish is to make collaborations *broad* with specific wishes to include soil scientists and field managers that would provide opportunity to feel and learn about soils more closely.

Space: Soil (health) education is almost non-existent in primary schools in Poland, and related courses are predominantly conducted indoors, specifically inside classrooms. The wish is to offer soil (health) education that combined indoors and outdoors approaches.

> The challenge is the core curriculum, the number of hours and all sorts of restrictions when it comes to going out with students. For example, a parent might not agree to their child's participation. Then someone has to look after those (students) who stay.
> -A *primary school teacher (from interviews)*

Process: The process is mainly *instructive* with occasional instances of *emancipatory* approaches. For example, the subject 'Environment' (Grade IV) facilitates interactive and exploratory learning approaches where students are encouraged towards making observations, interpretations and problem-solving activities. The wish is to transition towards education process which is more *emancipatory*.

Activities: In the primary education, the mainstream education appears to adopt predominantly *Knowing-based* activities, with occasional *doing-based* activities. *Being-based* activities are generally absent. The wish is to facilitate soil (health) education through a balance of *knowing-, doing-* and *being-based activities* where, acquiring information, hand on activities and developing a personal relation and care for soil complement and reinforce each other.

> Once the student has the knowledge, he can then refer to it himself in practice if he needs it. He can then apply it in doing and being. He can also refine the knowledge he has acquired, extend it, deepen it.

Paradigm: A review of syllabi indicates a greater emphasis on *mechanistic* paradigm; however the interview with related experts suggest that both *mechanical* and *ecological*

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paradigms are present—sometimes overlapping and sometimes connecting with each other. The wish is to follow an integration of both *mechanistic* and *ecological* paradigm.

Gaps, challenges & opportunities

Soil (health) is largely missing from the primary school curriculum in Poland and children lack essential knowledge about soil, its functions and importance for SDGs, especially in urban areas, presenting a significant gap. To address this gap, the soil (health) topics need to be incorporated in the curriculum, ideally making *hands-on activities* (like soil experiments) mandatory to make learning more engaging and spark students' imaginations. Furthermore, an interdisciplinary approach where soil (health) topics are integrated across biology, math, and chemistry could further create a more holistic understanding of soil.

> Start with understanding, and only then you can move on to being.
> -A *primary school teacher (from interviews).*

However, such reforms would be challenged by logistic and administrative hurdles which include parental concerns and creating a plan to accommodate students with a diversity of needs and abilities, in addition to expanding the time and resources available to teachers. Addressing these challenges further requires enabling the teachers to embrace new approaches.

Given that teachers have freedom in educational process, they can work towards 'wished' approaches as resources permit, offering an opportunity for innovation in the educational process.

Secondary education

Vision: To incorporate soil (health) education within the core curriculum and make clear connections with SDGs.

Needs: To create conducive conditions for teachers and students via allocating resources andmanageable responsibilities, and reducing organizational complexities to allow for more outdoor and collaborative education.

Opportunities: Teacher's freedom in applying educational approaches offers a potential to advance towards the 'wished' approaches conducing innovation in teaching methods.

State and wishes of soil (health) education

Purpose: The soil (health) education in secondary schools addresses certain aspects like *reducing soil pollution and enhance restoration*, *reducing desertification, and Stopping soil sealing, improving soil structure to enhance soil biodiversity, preventing erosion thus showing some connections the Mission Soil objectives,* however, the connections with broader SDGs are missing except indirect and weak connections to the *responsible consumption and production, e.g. in Geography extended - 'XIX (ORE), the* relationship of agriculture to climate, landforms, soil fertility and water resources are presented. The wish is to increase attention to *responsible consumption and production*.

While the syllabi does not explicitly mention most of the SDGs and Mission Soil objectives, their connections with soil are likely mentioned. How the role of soil (health) within the

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broader context of SDGs is presented depends heavily on the teacher's decisions and instructional approach as well as the 'educational level' of the students. For instance, at basic profile, students are expected to have a basic factual knowledge of soils (e.g. soil types). An 'extended profile' entails this knowledge be deepened and linked to a broader context (e.g. food security).

In terms of human development, soil (health) education has the main purpose of transferring and acquiring knowledge about soil (health) (*Knowing*), with limited components of experiential learning (*Doing).* There is a lack of focus on fostering personal connections with soil and developing a sense of care and responsibility towards it (*Being*). The wish is to shift towards a an approach to soil (health) education that incorporates *knowing* and *doing*.

Collaboration: Soil (health) education in secondary schools in the Poland is predominantly *narrow* with limited involvement of external partners. The wish is to extend it towards *narrow-broad*, with specific interest of involving specialists working with soil so that students can expand their knowledge and learn about its practical implementation.

Space: Soil (health) education in secondary schools occurs primarily *indoor,* in the classroom setting, which is almost always indoor at 'basic' level with some outdoor components at 'extended level'. *Outdoor* activities often involves taking sail samples or doing a soil profiling. No insights on the 'wished' learning space could be gained, however it was indicated that teachers feel constrained in organising *outdoo*r activities due to financial constraints and limited time to accommodate all teaching responsibilities.

Process: The process is mainly *instructive,* and there are only few examples of *emancipatory* forms of education in the extended courses, where students actively shape their learning process (e.g. Geography extended (ORE)). The wish is to have a balanced approach to soil (health) education at the secondary level, continue with the educational processes as they are where basic level is facilitated via *instructive* processes with some *emancipatory* activities (e.g. workshops) at 'extended' levels.

Activities: In secondary education, *knowing-based* activities predominate soil (health) education. *Doing-based* activities are weakly present, and they in the 'extended' or advanced levels. '*Being-based*' activities are generally absent. The wish is to strengthen the *doing-based* activities which also attracts more interest from students.

Paradigm: At the basic (secondary) level, there is dominance of a *mechanistic* paradigm. At this level the goal of the course is to let students acquire basic knowledge of soil. Therefore, interview participants considered it sufficient and age-appropriate. At the advanced (secondary) level, *ecological paradigm* is more prominent and discussions focus on ecological relationships among different environmental components including soil. No insights on the wishes were gained.

Gaps, challenges & opportunities

The core curriculum in secondary education in Poland lacks the specific mention of soil (health) and also misses on how soil (health) is connected to the EU's Mission Soil goals or Sustainable Development Goals (SDGs). In addition, the curriculum appears to be very

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intensive in terms of the number of facts presented within limited teaching hours, thus making it challenging to both learner and teachers. Alongside, there is need for more hands-on learning opportunities to allow engaging and experiential learning about soil (health), which may benefit from making such courses compulsory.
A crucial finding that emerged is the lack of time available to teachers, and financial and organisational constraints to allow for more *outdoor, doing-based* and *emancipatory approaches*. These constrains also include inaccessibility to universities (rural school being most disadvantaged at this) and lack of suitable accessible sites for field trips.
All these challenges call for a radical reorientation of curricula where soil (health) should be incorporated without intensifying the knowledge students are expected to acquire, but also allocating more resources for supporting teachers.

> It's all about doing it in the field. It's hard to be effective at virtually all levels when you have few hours at your disposal.
> *-A secondary school teacher (from interviews).*

Tertiary education

Vision: To establish soil (health) education to facilitate its holistic understanding and its connections with broader SDGs and EU Mission Soils.
Needs: To reorient the education to strengthen the focus on soil (health) under multi-disciplinary settings and to transition towards more experiential learning by exposing students to real-world issues.
Opportunities: There are opportunities to increase collaboration and balance instructional methods with more emancipatory processes within existing settings.

State and wishes of soil (health) education.
Purpose: While soil (health) is not explicitly mentioned in tertiary level educational offers, it is indirectly addressed in soil science and related courses (e.g. agriculture, forestry, environmental protection etc.) which are offered across 50 Bachelor degree programs offered across 22 public universities in Poland. Focus of these programs primarily revolves around soil conservation issues and in Mission Soil objectives such as *improving soil structure to enhance soil biodiversity*, *conserving soil organic carbon stocks*, *Ppreventing soil erosion, reducing desertification* as well as on *improving soil literacy in society* (e.g. Soil Science and Geography course by Jagiellonian University*).* However, *stop soil sealing, increase reuse of urban soils* and *reducing the EU's global impact on soils* are generally missing. In terms of the SDGs, soil (health) linkages are missing and only indirectly addressed in the context of food security (*zero hunger*), with some weak connections *to responsible consumption and production* (e.g. Geography course by UAM). Connections of soil (health) to other SDGs are missing. The wish for soil (health) education is to strengthen certain key aspects — *reducing the EU global footprint on soils* and *improving soil literacy in society*. In terms of human development, the primary focus particularly in university courses seems to be on gaining knowledge (*knowing*) about soil properties and processes, of soil biodiversity, and of soil as a system of relationships and interactions

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(Geography course by UMCS Lublin). There is relatively less focus on experiential learning (*doing*) , and understanding personal relationships (*being*) is missing The wish is to increase the focus on *doing*, and *being*.

Collaboration: Tertiary level soil (health) education was found to have predominantly *narrow* collaboration, primarily involving students and teachers. In specialised universities, for instance agricultural universities and polytechnics, academics and practitioners (e.g. farmers, foresters, civil servants, service providers, agricultural advisors) collaborate thus expanding to *narrow-broad* collaboration. *Broad* collaborations are missing. The wish is to have *narrow-broad* to *broad* collaborations in soi (health) teaching.

Space: In tertiary soil (health) education, outdoor learning opportunities are weakly embedded and usually in form of field exercises. Educationis predominantly offered *indoors* (classrooms and laboratories). The wish is to have balanced components of both *indoor* and *outdoor* learning.

Process: At the tertiary level, soil (health) education primarily relies on instructive processes and *emancipatory* processes are weakly embedded. The wish is to facilitate soil (health) education predominantly via *emancipatory* processes.

Activities: At the tertiary level of education in Poland, soil (health) education primarily emphasizes *knowing-based* activities with some *doing-based* activities. *Being-based* activities are missing. The wish is to strengthen the *doing-based* activities in soil (health) education.

Paradigm: Both *mechanistic* and *ecological* paradigms are present in tertiary level soil (health) education in Poland, however, the *mechanistic* paradigm dominates. The wish is to have a balance of both paradigms which facilitates for deeper understanding of specific processes, while also for understanding interrelationship across different processes.

Gaps, challenges & opportunities.

Despite soil science being a widely offered course in Poland, the focus largely remains on the *mechanistic* and technical aspects of soil properties and processes.Additionally, the connections of soil (health) with sustainability goals and Mission Soil objectives are missing which indicates that soil (health) is overlooked. In terms of educational approach, predominance of *instructive* approaches and lack of multidisciplinarity and experiential forms of learning presents a gap in preparing students for real-world soil (health) issues, in addition to the limited time allocated to soil related topics.

To narrow these gaps, curriculum needs to be revised to incorporate compulsory field exercises and shift from lecture-based to experiential learning, and making soil (health) courses more interdisciplinary, for instance via thematic group teaching where experts of different disciplines can design and execute the course. Such changes might face resistance, especially among those used to conventional teaching methods and older academics. Such changes, however, offer an opportunity to create an educational system where students can develop more holistic understanding of soil (health) and have more practical tools to address the real-world challenges.

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Vocational educational training (VET)

Vision: To incorporate a specific focus on soil (health) topics within VET programs and integrate this with broader public awareness on soil (health).
Needs: To allocate resources to revise VET curriculum to strengthen the focus on soil (health) and to transition towards more active and soil (health) focussed activities in real-world.
Opportunities: To develop soil (health) educational offers and approaches that can be used for VET as well as general public.

State and wishes of soil (health) education

Purpose: In vocational education in Poland, soil (health) related topics vary and Mission Soil objectives and SDGs, are only addressed indirectly. There is some emphasis on soil conservation topics, especially *reducing desertification*, *preventing soil pollution*, *preventing erosion*, and biodiversity conservation, e.g. *improving soil structure to enhance biodiversity*. Agricultural technical schools and Ecological Folk High School (EFHS) cover a range of SDGs, including *gender equality, sustainable cities and communities*, and *climate action*, within the context of agriculture. The wish is to strengthen the emphasis on *improving soil literacy in society, reducing soil pollution and enhance restoration, stopping soil sealing and increasing the reuse of urban soils* and to expand the soil educational offers available to students beyond core curriculum e.g. via films and offers available to general public. Interview with VET representative suggested that there is intention to develop education to raise awareness on importance of soil, and thus offers an opportunity to incorporate these connections. A review of course curriculum indicates that predominant focus of soil (health) education at the VET level in terms of human development is on "*doing*" which aligns with the fact that VET courses are aimed towards development of professional skills. However, interview with VET representative provided an insight that all three-*knowing, doing* and *being* are present and in case of EFHS, firmly in place. In case of Agricultural technical schools, the emphasis is higher on *knowing* about soil and the best practices to protect its state followed by *doing,* and *being* is weakly embedded. There is a clear wish for a balanced approach to EFHS courses where all three — *knowing, doing*, and *being* are present. In case of Agricultural Technical Schools, the wish is to reinforce *being.*

> One should not limit oneself to school, but also take care of these issues at the level of public awareness
> *–A VET representative (from interviews)*

Collaboration: Collaborations in Soil (health) education in VET in Poland is *narrow-broad* to *broad.* Students and teachers often engage with external partners and stakeholders mainly via student apprenticeships. These partners include farmers, agri-businesses, public and non-public units related to agri-food services as well as with policy related bodies like state forestry management, etc. Maintaining and further broadening collaborations emerged as a strong wish.

> Collaborating in a spirit of dialogue, we avoid the arrogance of practitioners and the arrogance of theorists
> *–A VET representative (from interviews)*

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Space: Most soil education VET programs are designed to take place both *indoors* and *outdoors*. VET schools have *outdoor* thematic vocational laboratories (e.g. agricultural production laboratory) which are mostly outdoors, as well as regular courses in farms or agricultural holdings which includes croplands, meadows, pastures etc) which act as 'place of realisation' for professional practices. These complement the *indoors* learning in classrooms and laboratories. However, soil (health) is weakly present (e.g. outdoor soil laboratories are limited) and is limited to soil sampling and analysis to know the nutrient status. The wish is to transition towards more *outdoor* learning.

> There is a lack of educational popular science films in this (soil (health)) area... It has to be a film that is shown to the whole society, because in fact, the whole of society is responsible for the state of the soils in our country.
> *–A VET representative (from interviews)*

Process: In Agricultural Technical Schools, both *instructive* and *emancipatory* processes are present, however, their relative weights depend on the course objectives. The wish is to further strengthen *emancipatory* process.

Activities: The VET education in Poland is mainly facilitated by *doing-based* activities. Agricultural technical schools place strong emphasis on learning by doing and facilitate this through well-equipped laboratories (e.g. plant production laboratories) where students perform experiments, measurements (e.g. soil testing, climatic measurements etc.). However, in certain courses such as soil chemistry (Chemistry IV), there is more focus on theoretical knowledge aquisition about soil properties and processes. *Being-based* activities are weakly embedded and are likely to result from the *knowledge-based* and *doing-based* activities implemented at the technical schools. In case of EFHS, all three—*knowing-based*, *doing-based* activities are present, with some emphasis on *being-based* activities. No insights on whe wishes could be gained. Paradigm: In VET programs, soil (health) education is approached via a combination of both *mechanistic* and *ecological* paradigms. In Agricultural technical school, *mechanistic* paradigm prepares the base for approaching from *ecological* paradigm. The wish is to strengthen *ecological* paradigms.

Gaps, challenges & opportunities

In VET education in Poland, there is lack of explicit focus on soil (health) in core curricula, reflecting an oversight of the topic. The educators seem to recognise importance of soil (health) education, already intensive curricula leaves limited room to incorporate soil (health) topics comprehensively. Additional challanges include limited funding to transition towards 'wished' educational approaches. Lack of public awareness towards environmental further impede efforts to enhance soil (health) education. To address these gaps, the VET education on soil (health) may be expanded beyond the formal curriculum and take advantage of offers available outside (e.g. those available to general public) and to prioritise approaches which are more attention drawing and engaging (e.g. films and workshops). Therefore, creating such resources would benefit soil (health) education in VET and beyond.

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General public

Vision: To create an accessible and comprehensible educational offers based on innovative approaches and collaborations across educational system, policymaker and mass media.
Needs: To allocate resources to incorporate soil (health) topics in at different educational levels alongside creating offers for general public and foster collaborations.
Opportunities: To leverage on resources such as nature trails and city greenery programs offer to incorporate education on soil (health)..

State and wishes of soil (health) education

Purpose: Soil (health) education initiatives for the general public in Poland align closely with policies related on environment, land use and agriculture. These policies also address several of the Mission Soil objectives and SDGs. For instance, Article 101, 'law on environmental protection', and the 'law on the protection of agricultural and forestry land' address *conserving soil organic carbon stocks and enhancing restoration, preventing erosion, improving soil literacy in society and* also weakly focus on *stopping soil sealing and increase re-use of urban soils, reducing soil pollution and enhance restoration. Such activities are offered, for example, by the Soil Museum in Krakow.* While these policies do not mention specific SDGs, they have focus on sustainable development in a broad sense. Specifically, Art. 1 refers to the principles of environmental protection and the conditions for the use of its resources, taking into account the requirements of sustainable development (Prawo ochrony środowiska, 2001). In terms of human development, the focus is on *knowing* which is facilitated via mass media alongside different courses offered across schools and other levels. For instance, Environmental Protection Act specifically directs to include environmental protection and sustainable development issues in the core curriculum of general education for all types of schools as well as its dissemination via mass media with an aim to shape a positive attitude of the public towards environmental protection. Issues of environmental protection and ecological development are included in the core curricula of all types of schools, but to a very different extent, but soil issues are not clearly accepted. In the mass media, soil issues are often discussed in nature and agricultural programs (e.g. https://agrobiznes.tvp.pl/52190323/programy) However, specific focus on soil could not be found in these policies. There are some offers which include *doing* aspect which is deliberated towards cultivating more positive behaviours (*being*). For instance programs such as "Garden with class" offered by Urban Greenery Management (Zarząd Zieleni Miejskiej w Krakowie, 2024) aimed to inspire and support kindergartens and primary schools to set up school gardens. Similarly, the course "Teacher close to nature" (Zarząd Zieleni Miejskiej w Krakowie, n.d.) aimed to disseminate methods of working with children that use contact with nature as a factor supporting development and education. Many topics from the core curriculum can be successfully implemented in the field. More and more scientific research shows that children learn faster if their learning is based on direct references to nature, on experiencing nature, rather than on theoretical concepts. The wish is to transition towards a combination of *doing* and *being* as purposes.

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Collaboration: Insights on collaboration within soil (health) awareness offers for general public were predominantly gained from the interviews. Collaboration is found to be *broad* and includes students and decision makers as collaborators. *Broad* and *narrow-broad* are also the wished forms of collaboration.

Space: Insights on learning space within soil (health) awareness offers for general public were solely gained from the interviews. Learning space is found to be predominantly *indoors* with weak components of *outdoors* education, which is attributed to lack of access to suitable outdoor spaces, especially in urban areas. For instance, not all schools have a garden, and most soils are predominantly 'anthropogenic' i.e. formed or heavily modified resulting from human activities (e.g. from irrigation, organic amendments, certain cultivation practices etc.) which limits opportunities of experiencing 'natural' soils. The wish is adopt a combination of *outdoor and indoor* learning.

Process: Insights on 'process' within soil (health) awareness offers for general public were solely gained from the interviews and are found to be facilitated predominantly through instructive processes with some component of *emancipatory* process. For instance, there are organisations that hold community consultations or thematic groups where they gain knowledge on specific topics (e.g. composting) via educational materials (e.g. leaflets). Certain initiatives are beginning to adopt an *emancipatory* approach to address socioeconomic and environmental issues. The wish is to transition towards higher components of *emancipatory* process.

Activities: Insights on 'activities' within soil (health) awareness offers for general public were solely gained from the interviews and are found to be predominantly focussed on *Knowing-based* activities with weaker components of *doing-based* activities, e.g. via participating in citizen science projects. *Being-based* activities are generally absent and likely emerge as a consequence of *knowing-* and *doing-* based activities. No insights in the 'wishes' for activities could be gained.

Paradigm: Insights on 'activities' within soil (health) awareness offers for general public were solely gained from the interviews and are found to be predominantly focussed on *ecological* paradigm. The wish is to keep following *ecological* paradigm.

Gaps, challenges & opportunities

There is little awareness amongst general public residents regarding soil (health) and there is a need to create educational offers for general public. This would require creating educational offers in a simpler non-technical languages and identifying innovative approaches that allows for integrating soil-related topics into different educational levels and contexts. Additional challenges include financial constraints, limited personnel, and limited opportunities of engaging policymakers (e.g. local municipalities) within potential educational initiatives related to soil (health).

To address these, the curriculum needs allocation of resources (financial, educational and time) dedicated to soil (health) topics and to expand the educational outreach. Furthermore, there is a need for continuity in implementing long-term plans regardless of changes in

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leadership. Leveraging resources such as nature trails and city greenery programs offer an opportunity to incorporate education on soil (health).

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A.10. Serbia

Soil (health) education in Serbia aims to align with EU mission goals and Sustainable Development Goals (SDGs), but several challenges interfere with its implementation across various educational levels and the general public. In primary education, there is a clear need for better teacher training and educational materials on soil (health). Soil (health) topics are often missing from the curriculum, particularly in urban areas, which makes it challenging to emphasize their importance and raise student awareness. Improving collaboration between teachers of different subjects and between schools and external educators could be beneficial to enhance soil (health) education at the primary education level. The wish to integrate complex soil topics is shared also by the secondary education sector. Promoting SDGs connections and multidisciplinary approaches face logistical challenges and an examination driven system that limit exploratory and emancipatory teaching methods. However, extracurricular activities such as educational team competitions, problem-solving discussions, and creative methods, moderately used at this educational level, can foster an ecological and holistic approach. Tertiary education needs to treat soil (health) topics through experiential learning (*doing-based* activities) and to cultivate values (*being*) among students. Utilizing modern educational methods and already existing outdoor education facilities can foster a multidisciplinary and real-world problem-solving understanding. Tertiary education currently favors specialized expertise over holistic understanding. For the general public, introducing soil (health) topics as contemporary and urgent issues is crucial. Forms of collaboration involving agricultural stakeholders, private companies, and teaching facilities can improve soil (health) education for general public.

Primary education

Vision: to foster a comprehensive understanding of soil (health) that integrates with the SDGs, promoting a global and holistic perspective among students from an early age.
Needs: To equip teachers with a better training and educational material on soil (health) and to improve collaboration between teachers of different subjects and between schools and external educators.
Opportunities: Field trips, excursions, school gardens, and extra-curricular activities can provide practical, hands-on, and outdoor learning experiences.

State and wishes of soil (health) education.

Purpose: Soil (health) education in primary schools in Serbia address specific Mission Soil objectives, such as *reducing soil pollution and enhance restoration, preventing erosion, improving soil literacy in society reducing desertification, stopping soil sealing and increase re-use of urban soil, and improving soil structure to enhance soil biodiversity*. In primary education, lessons about soil (health) begin, in early age, with basic concepts of soil in relation to nature and environmental protection. As students progress to higher grades, they are introduced to more advanced soil (health) topics through subjects like biology and geography. These curricula often cover the types of soil, erosion and how soil (health) sits within the context of food production, plant life, climate change, and

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pollution. Local examples of pollution, microplastics, and the irresponsible use of chemical additives and fertilizers are also discussed. Moreover, students learn about erosion in their regions and ways to improve the food system. There is the wish to strengthen to the purpose of soil (health) education, specifically, in connection with *reducing desertification, conserving soil organic carbon stocks, stopping soil sealing and increase re-use of urban soils, reducing soil pollution and enhance restoration, preventing erosion, improving soil structure to enhance soil biodiversity, reducing the EU global footprint on soil, improving soil literacy in society.* In terms of SDGs, *no poverty, zero hunger, good health and well-being, quality education, clean water and sanitation, climate action, life below water, life on land* are predominantly embedded in the purpose of soil (health) education. Soil (health) is generally not taught in reference to SDGs in primary education. This educational level is dealing merely with most basic concepts and some ecological, food and climate-related topics in connection with soil. The wish is to include SDGs in relation to soil (health) in the curricula, in a form that is appropriate for the primary level of education but that develops a more global and holistic way of thinking where it is clear that soil (health) and SDGs are interconnected and have an impact on each other. The wish is to particularly emphasize *zero hunger, good health and well-being, quality education, sustainable cities and communities, responsible consumption and production, climate action, life below water, and life on land*.

In terms of human development, the purpose of soil (health) education is focused primarily on *knowing* and *being*. Soil (health) topics are taught as general knowledge, and the purpose is to inspire pupils to take responsible behaviour towards nature and the environment. There is a clear need to include the *doing* aspect in shaping the purpose of soil (health) education. The wish is to include *knowing, doing,* and *being* in the purpose of soil (health) education.

Collaboration: Soil (health) education in primary schools in Serbia is predominantly *narrow.* Generally, soil (health) education involves exclusively primary education teachers. Interviews reveal examples in which collaboration becomes *narrow-broad* but also suggest that teachers are not sufficiently prepared and equipped with good educational material on soil to broaden certain collaborations. The inclusion of other types of skills and knowledge seems important for developing soil (health) education. The wish is to make collaborations *broad*. Students would benefit from being involved in extracurricular activities with different educators and mixed approaches, such as project-based learning and teams of teachers from different subjects teaching about the same topic from different perspectives.

Space: Soil (health) education primarily takes place *indoors* at the primary education level, specifically in classrooms. *Outdoor* educational activities related to soil are almost absent in the curriculum. Although some educational materials recommend activities for *outdoor* learning, they are

> Organizing extra-curricular activities, mainly outdoor activities, such as field trips, costs a lot and is demanding timewise to organize if schools don't already have green backyards, gardens or similar.
> *–A primary school teacher (from interviews).*

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insufficient. Field trips and excursions rarely provide opportunities for soil (health) education to be brought outside and to be incorporated into the primary school curriculum, and even when they do, these activities are not mandatory. Not all schools have the opportunity or capacity for *outdoor* learning, especially those located in urban areas. Teaching is generally oriented towards classroom-based *indoor* learning. There is a wish for soil (health) education to occur *outdoors*, for example, through school gardens and field trips.

Process: The process is mainly *instructive* with occasional instances of *emancipatory* approaches, where educational materials suggest the inclusion of experiments or instructions on independently making things. However, not enough *emancipatory* practices are offered. In higher grades, some practical lab work in chemistry is done if the school has the facilities, but not from the perspective of soil (health) and not in all schools. Composting and similar topics seems to offer space for implementing this kind of educational process. Schoolwork significantly follows a traditional instructive approach, where few extracurricular and elective activities even if have a more *emancipatory* approach they often do not majorly count towards the overall grading. The wish is to transition towards a more *emancipatory process*. This includes activities such as group work and group teaching, student projects, experiments, and problem-solving. Learning through self-discovery is emphasized.

> [Students should have the opportunity] to see, feel and touch and learn through the geological collection of stones and rocks, then soil samples, pedology cartography, and an opportunity to ask questions and learn through dialogue.
> *–A geography teacher (from interviews).*

Activities: In primary education, soil (health) appears to adopt predominantly *knowing-based activities* but also includes partially *doing-based* and *being-based activities*. Most of the educational material provides knowledge and describes good practices and values to implement, but they are still mostly knowledge based. In older classes, from grade five, there are knowledge competitions in subjects such as biology, geography, and others, but these are mostly theoretical. *Being* and *doing-based activities* need to be more developed and incorporated into soil (health) education, especially from an early age at the primary education level when habits and values are easily taken in. The wish is, therefore, to incorporate more *doing- and being-based activities* suitable for primary education pupils, such as collecting data, measuring and comparing, and any involvement in direct experimenting, for example, microbats, pH level measuring, etc.

Paradigm: A review of syllabi indicates a greater emphasis on mechanistic paradigms. Although the ecological paradigm is not widely present at higher levels and should be improved, in lower grades of primary school, topics are introduced from a more ecological and holistic perspective. This is because specialized knowledge is not largely required at that age, allowing students to gain general knowledge about wellbeing and health, including the wellbeing and health of nature (soil,

> From personal effort of teachers, a lot can be done, bit teachers need good instructions and materials.
> *-A chemistry teacher (from interviews).*

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air, water, etc.).. Students get general knowledge about wellbeing and health, including the wellbeing and health of nature (of soil, air, water etc.). This allows children to be exposed to ecological thinking and to learn about good practices and their connection to the wider picture. The wish is to adopt an *ecological paradigm*, with the possibility of including ecological thinking and practices in everyday school life, even if the system could be resistant to this change.

Gaps, challenges & opportunities

The topic of soil (health) is largely missing from the primary school curriculum in Serbia, and children lack essential knowledge about soil, its functions, and its importance for SDGs, especially in urban areas, presenting a significant gap. The challenge is to motivate and emphasize the importance of these topics to raise awareness among students. Since young pupils can easily adopt new topics, this presents an opportunity to start with environmental education, and soil (health)-related topics, from an early age to foster better changes. The challenge is how to introduce and explain complicated SDG topics to children and to adapt those topics to this specific educational level. To address this gap, soil (health) topics need to be incorporated into the curriculum. Collaboration needs to be improved and could attempt to connect different subjects and teachers around the shared topic of soil (health). This is a good opportunity for soil (health) education but is complex to organize and implement when it lacks structural support, as it is not part of the official curriculum requirements. Furthermore, teachers need more preparation and school material on soil (health). Excursions and field trips constitute an opportunity to bring soil (health) education outside. There is a need for more *outdoor* education. Excursions and field trips constitute an opportunity to bring soil (health) education outdoors. However outdoor activities are costly and time-consuming to organize if schools don't already have green backyards, gardens, or similar spaces. Schoolwork significantly follows a traditional approach, with few extracurricular and emancipatory activities.

Secondary education

Vision: To integrate complex soil (health) topics into the curriculum, emphasizing connections with the SDGs, and promoting a multidisciplinary approach.
Needs: To address logistical challenges and the exami-driven nature of the secondary education system to allow for more exploratory and emancipatory teaching methods.
Opportunities: To use extracurricular activities such as educational team competitions, problem -solving discussions and creative methods to encourage an ecological thinking among students

State and wishes of soil (health) education

Purpose: The soil (health) education in secondary schools addresses certain aspects like *reducing desertification; stopping soil sealing and increase re-use of urban soil, reducing soil pollution and enhance restoration, preventing erosion, improving soil structure to enhance soil biodiversity* and *improving soil literacy in society*. Soil (health), although not called like that, is often present as a topic, within other subjects or through elective

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courses in rare occasions. Little emphasis is given to global soil-related problems. The wish is to emphasize the EU Mission Soil goal of *reducing desertification, conserving soil organic carbon stocks, stopping soil sealing and increase re-use of urban soils, reducing soil pollution and enhance restoration, preventing erosion, improving soil structure to enhance soil biodiversity, reducing the EU global footprint on soils,* and *improving soil literacy in society* when defining the purpose of soil (health) education. However, these are considered complex topics that are hard to include in secondary education level. The connection between soil (health) and SDGs is not strongly underlined, but it is merely mentioned in some contexts. The connection between soil and food system, agriculture and environmental protection are emphasized and taught only in specific and specialized secondary school. The SDGs *no poverty, zero hunger, good health and well-being, quality education*, *clean water and sanitation*, *affordable and clean energy*, *sustainable cities and communities*, *climate action*, and *life on land* even if included in a limited approach, they contribute to the purpose of soil (health) education. The wish is to emphasize the existing connections with the SDGs while also including the goals of *decent work and economic growth, industry, innovation and infrastructure, reduced inequalities, responsible consumption and production,* and *life below water* when shaping the purpose of soil (health) education. Interviewee from the secondary education level suggested that SDGs can be taught further through different educational activities such as educational team competitions on soil (health) topics or problem-solving exercises where students have the opportunity to study soil (health) related subjects, engage in discussions and explore how soil-SDGs nexus can be addressed locally.

In terms of human development, soil (health) education has the main purpose of transferring and acquiring knowledge about soil (health) (*Knowing*), with limited components of experiential learning (*Doing).* There is a lack of focus on fostering personal connections with soil and developing a sense of care and responsibility towards it (*Being*). The wish is to incorporate *knowing*, *doing*, and *being* when defining the purpose of soil (health) education. The challenge of including *being* and presenting soil topics in a way that keeps secondary education students engaged and interested remains.

Collaboration: Soil (health) education in secondary schools in the Serbia varies from *narrow* to *narrow-broad*. The current approach to soil (health) education offers opportunities for collaboration between different disciplines and teachers with various areas of expertise through project-based teaching in secondary education. The wish is to move towards a *broad* collaboration. *Broad* collaboration does not take place sufficiently and often only in specialized secondary schools. There is a clear need to shape soil (health) education through a multidisciplinary lens and to foster school-to-school collaborations. The challenge lies in the shortage of time for teachers and the lack of finances and equipment necessary to promote such broad collaboration. Teachers are willing to collaborate, but their specialized training can sometimes be a challenge, making it difficult to unify different approaches.

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Space: Soil (health) education in secondary schools occurs primarily *indoor*. Availability of space and logistical issues appear to be the major impediments to the development of outdoor activities related to soil (health). In addition, secondary education is mainly exam-driven, which allows limited time for exploratory and outdoor teaching. Only specialized vocational secondary schools have labs or school farms that provide opportunities for outdoor education. There is a wish to include more *outdoor* activities when designing soil (health) education. Interviewees mention the possibility of designing toolkits for outdoor learning that can be easily implemented in different contexts.

Process: The process is mainly *instructive,* and there are only few examples of *emancipatory* forms of education, mostly in vocational secondary schools that give space to agriculture and laboratory-oriented learning. Generally, secondary education is exam-driven and there is little opportunity for exploratory and *emancipatory teaching.* The wish is to have an *emancipatory* approach when facilitating soil (health) education. Interviewees suggest the integration of group projects, team competitions and problem-solving educational activities into the curricula, in order to foster the *emancipatory process*.

Activities: In secondary education, *knowing-based* activities predominates soil (health) education. '*Being-based*' activities and doing-based activities are generally absent. Nowadays, vocational secondary schools provide students with practices and skills that are more exploitative and are less oriented towards preserving soil. The wish is to facilitate soil (health) education through knowing, *doing, and being-based* activities. Secondary school stakeholders see the importance of including practical activities, as they have the potential to promote job skills and new practices oriented towards general environmental and soil protection.

Paradigm: At secondary education level, there is dominance of a *mechanistic* paradigm. The *ecological paradigm* is gaining more and more attention; however, it is seen as difficult to implement. The wish is to shape soil (health) education through an *ecological paradigm*. Creative educational activities and methods, such as showing films and documentaries, are seen as valid tools to encourage holistic and ecological thinking among students.

Gaps, challenges & opportunities

Soil (health) education varies significantly across different types of secondary schools. Gymnasiums, which provide broad-spectrum, general, and more theoretical education, offer a different approach compared to secondary vocational schools, which focus on practical, applied knowledge, particularly in agriculture, preparing students directly for the job market.. This results in a variety of teaching materials and a better understanding of soil-related topics in vocational secondary schools. There is a clear need to renew educational approaches that can facilitate the introduction of complex soil topics into secondary education. Soil (health) education currently treats mainly the economic and exploitative aspects of agriculture and food systems but lacks a multidisciplinary approach and school-to-school collaborations. The exam-driven system leaves little room for exploratory and emancipatory teaching. Cultivating the *being* and fostering engagement for soil (health)-related subjects among students can be achieved through extracurricular activities such as

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educational team competitions and problem-solving discussions, also in strict connection with the SDGs-soil nexus. However, all these initiatives and new approaches face organizational issues and time limitations within the curriculum. The introduction of creative methods gives the possibility to foster holistic and ecological thinking among students.

Tertiary education

Vision: To create a comprehensive and integrated program that aligns with the Mission Soil objectives and Sustainable Development Goals (SDGs).
Needs: To increase the focus on experiential learning (*doing*) and cultivating values (*being*) in soil (health) education.
Opportunities: To utilize modern educational methods and outdoor education facilities to enhance multidisciplinary and real-world problem-solving experiences in the curriculum.

State and wishes of soil (health) education.

Purpose: Tertiary education programs related to soil (health) in Serbia focus primarily revolve around soil conservation issues and in Mission Soil objectives such *reducing desertification, conserving soil organic carbon stocks, stopping soil sealing and increase re-use of urban soils, reducing soil pollution and enhance restoration, preventing erosion,* and *improving soil structure to enhance soil biodiversity.* However, education materials, in tertiary education, are often very specialized and segmented and hardly deal with broader aspects such global soil issues or soil literacy. The wish is to include all the Mission Soil objectives in the purpose of soil (health) education. However, this aim reinforces the challenges of educating and developing future graduates as experts in soil (health) who can be versatile and impactful across various soil-related issues. In terms of the SDGs, soil (health) linkages are only indirectly addressed in connection to *zero hunger, quality education, clean water and sanitation, industry, innovation and infrastructure, reduced inequalities, sustainable cities and communities, responsible consumption and production, climate action, life on land, and good health* and *well-being.* SDGs, and in relation to soil, appear to not be the predominant topics at tertiary level. Tertiary education tends to be more fixed and reliant on current practices rather than embracing and implementing changes. The wish is to include and connect all the SDGs. Elective courses can provide a significant opportunity to connect soil (health) and SDGs.

In terms of human development, the primary focus particularly in university courses seems to be on gaining knowledge (*knowing*). There is relatively less focus on experiential learning (*doing*) while cultivating values (*being)* is absent when shaping the purpose of soil (health) education. Educational materials in higher education are often designed in order to inspire certain practices and provide specific theory on soil (health), and do not focus on developing "ways of *being*". The wish is to increase the focus on *doing* and *being*. Higher education teachers' autonomy in designing curricula can contribute positively to this shift, as formal educational systems are often slow in changing.

Collaboration: Tertiary level soil (health) education was found to have predominantly *narrow* collaboration, primarily involving students and teachers. *Broad and narrow-broad* forms

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of collaboration are weakly embedded. Specialized tertiary education typically involves smaller teams and a few close mentors focusing on highly specialized topics, leaving limited opportunities for broadening collaborations. There is a wish for both *broad* and *narrow-broad* collaborations. More extensive collaboration is needed in teaching and learning, preferably with industry, production, research, and innovation sectors, to expand collaboration opportunities.

Space: Tertiary soil (health) education is predominantly offered *indoors* and occasionally *outdoors* depending on discipline and field of education, and mostly in form of field exercises within agricultural studies. Most of the educational activities are conducted in classroom or laboratories (*indoor*), as most of the higher education is oriented towards theoretical learning. The wish is to have more components of *outdoor* learning. Higher education stakeholders underlines the need for *outdoor* teaching that can foster more comprehensive and multidisciplinary soil (health) education. This can be implemented by improving and increasing in numbers the already existing higher education research bases and stations for *outdoor* learning and by adding new specialized soil facilities.

Process: At the tertiary level, soil (health) education primarily relies on *instructive* processes and *emancipatory* processes are absent. Soil (health) education focuses mostly on transferring of theory and applied knowledge, such as analysis and lab work. The wish is to facilitate soil (health) education predominantly via *emancipatory* processes. Extracurricular activities and courses could facilitate the development of the emancipatory process in higher education. The wish is to facilitate soil (health) education predominantly via *emancipatory* processes.

Activities: At the tertiary level of education in Serbia, soil (health) education primarily emphasizes *knowing-based* activities with some *doing-based* activities. *Being-based* activities are missing. Academia and tertiary education usually do not focus on developing values and core morale towards the conservation and the sustainable management of the soil (health). Sporadically, some specific faculties, depending on the field of education, emphasizes the importance of sustainable practices, including soil exploitation and remediation practices. The wish is to strengthen and combine *knowing, doing* and *being-based* activities in soil (health) education.

Paradigm: *Mechanistic p*aradigms dominate in tertiary level soil (health) education in Serbia. Higher education curricula recognize the relevance of the ecological paradigm, but it is not the main focus and is therefore often underrepresented.. The wish is to have the *ecological paradigm* to shape soil (health) education at the tertiary level. The predominance of this paradigm would allow a stronger multidisciplinary approach and therefore an expertise joining and broader collaboration among academia, research and innovation sector. The main challenge for the establishment of the *ecological paradigm* lies in re-orienting soil (health) education from economically beneficial knowledge towards environmental beneficial knowledge and practices.

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Gaps, challenges & opportunities.

In Serbia, soil (health) education at the tertiary education level faces several gaps and challenges yet presents numerous opportunities for enhancement. Currently, education in this field lacks a comprehensive and integrated approach, whereas favoring specialized expertise over an *ecological* understanding.

Opportunities lie in using modern educational methods, such as technology and contemporary local problem-solving cases, to enhance sustainable *knowing doing*, and *being* -based activities. Institutions with *outdoor* education facilities represent a significant opportunity to integrate multidisciplinary and real-world problem-solving experiences into the curriculum. Moreover, extracurricular activities and teaching flexibility provide pathways for educators to introduce specific soil (health)-related activities, fostering a more practical learning experience.

Elective courses in higher education could be a strategic approach to introduce soil (health) topics, aligning with Sustainable Development Goals (SDGs) and the EU Soil Deal Mission, currently underrepresented in the curriculum. A comprehensive soil (health) education program that integrates these goals would create a more substantial connection between academic learning and global sustainability initiatives. Collaboration across various sectors—teaching, industry, production, research, and innovation—could further enrich the learning experience, ensuring that students gain practical, relevant skills that address current and future challenges in soil (health).

Vocational educational training (VET)

Vision: No comprehensive insights on the vision of soil (health) education at VET level could be gained

Needs: No comprehensive insights on the needs of soil (health) education at VET level could be gained

Opportunities: No comprehensive insights on the opportunities for soil (health) education at VET level could be gained

State and wishes of soil (health) education

Purpose: No insights on the Purpose of soil (health) education could be gained.

Collaboration: No insights on the Collaboration of soil (health) education could be gained.

Space: Most soil education VET programs are designed to take place *indoors*. VET tertiary level rarely have activities *outdoor* depending on the educational institution. Higher education schools may have labs or gardens where these activities can take place. No insights on the wishes could be gained.

Process: In VET schools the *emancipatory* process is dominant. Soil (health) education is often facilitated through practical activities such as lab work and *emancipatory* exercises. Education is practical, applied knowledge is present. No insights on the wishes could be gained.

Activities: No insights on the Activities of soil (health) education could be gained.

Paradigm: No insights on the Paradigm of soil (health) education could be gained.

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Gaps, challenges & opportunities

Soil (health) education at the VET level in Serbia is predominantly conducted *indoors*, with some *outdoor* activities depending on the educational institution. While some specialized higher education vocational schools have labs or gardens for practical activities, there is a general lack of integration of *outdoor* learning experiences in soil (health) education programs. Emphasizing *emancipatory* processes and practical activities, as already practiced in some VET schools, can serve as a model for broader implementation across VET education programs. There are no comprehensive insights available on the overall purpose, collaboration, activities, or paradigm of soil (health) education at this level. Vocational education is partially integrated with secondary education, as discussed in the section. Limited information is available regarding tertiary vocational education.

General public

Vision: to align with all the EU mission goals and SDGs, to strengthen the connection between soil (health) topics and the general public.
Needs: to introduce soil (health) topics as contemporary and urgent issues, emphasizing both doing and being-based activities to foster a more holistic understanding and engagement
Opportunities: collaborative efforts involving agricultural stakeholders, private companies, and teaching facilities can enhance public education through innovative practices like regenerative agriculture and permaculture.

State and wishes of soil (health) education

Purpose: Soil (health) education initiatives for the general public in Serbia address directly or indirectly all the EU mission goal: *reducing desertification, conserving soil organic carbon stocks, stopping soil sealing and increase re-use of urban soils, reducing soil pollution and enhance restoration, preventing erosion, improving soil structure to enhance soil biodiversity, reducing the EU global footprint on soils,* and *improving soil literacy in society*. Insights from the interviews reveal that the connection between soil (health) and the EU Mission Soil's goals of *reducing desertification, conserving soil organic carbon stocks, preventing erosion,* and *improving soil structure to enhance soil biodiversity is absent.* From the desk research insights, soil (health) appears to be largely present in informal materials for the general public. These materials are generally produced within projects and conferences with the aim of addressing the current state of soil (health) and desired improvements, thereby fostering change, raising general awareness, and promoting good practices. However, interviewees, from the general public education level, claim that soil (health) is not a widely recognized topic. They emphasised the urgency of addressing soil (health) challenges. Soil (health) and wellbeing is often treated in the contexts of agriculture, food export, and the mining industry, with an emphasis on better or proper exploitation rather than preservation. The wish is to include all the EU mission goals when shaping the soil (health) education purpose. However, it is

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wished to give a major emphasis on the following descriptors: *improving soil literacy in society, stopping soil sealing and increase re-use of urban soils, reducing pollution and enhance restoration*, *reducing desertification, conserving soil organic carbon stocks, preventing erosion,* and *improving soil structure to enhance soil biodiversity.*

In terms of the SDGs, soil (health) linkages are addressed in connection to *zero hunger, good health and well-being, clean water and sanitation, affordable and clean energy, industry, innovation and infrastructure, sustainable cities and communities, responsible consumption and production,* and *climate action.* General public educational material generally aims to produce changes and increase awareness in society and to emphasize the connection between soil (health) and the urgency of SDGs. SDG goals are not widely promoted or mentioned to the general public, except when they make news for crossing global limits. The wish is to include all the SDGs when shaping the soil (health) education purpose. The wish is to strengthen the SDGs of *no poverty; zero hunger, good health and well-being; climate action; sustainable cities and communities; responsible consumption and production; quality education; clean water and sanitation; affordable and clean energy; decent work and economic growth; industry, innovation and infrastructure.*

General public educational material generally aims to produce changes and increase awareness in society and to emphasize the connection between soil (health) and the urgency of SDGs. SDG goals are not widely promoted or mentioned to the general public, except when they make news for crossing global limits. The wish is to include all the SDGs when shaping the soil (health) education purpose. There is a possibility to implement public programs and workshops to raise awareness about these issues. However, a significant challenge is gaining institutional support for implementing solutions, especially when trying to apply EU policies or good practices from other countries, which are difficult to implement through the existing local system.

In terms of human development, the desk research reveals that *knowing* with emphasis on *doing* and *being* are the focus of soil (health) education purpose. On the other hand, interviewees claims that the current soil (health) education at general public level focus on the *knowing* while *doing* and *being* are absent or weakly embedded. In Serbia, general public education sporadically aims to advocate sustainable practices, though not directly regarding soil (health), through media campaigns. The space and media coverage for the promotion of good practices and values is limited. Reaching the population outside the big cities remains the main challenge. The wish is to emphasize *doing* and *being.* This would be a chance to give voice to alternative practices, such as regenerative agriculture or permaculture, and soil knowledge beyond conventional methods.

Collaboration: Collaboration is found to be *narrow Narrow-broad* collaboration is weakly embedded while *broad* forms of collaboration are absent. General public educational materials favour collaborative and community-connected practices and knowledge, as well as community-focused approach. Possible collaborations that could enhance open soil (health) education include, partnerships among agricultural sector stakeholders (e.g.,

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farmers), private companies, and teaching facilities. *Broad* is the wished form of collaboration. *Broad* collaborations, involving media, educational facilities, policymakers, NGOs, and various actors might help to reach the public more effectively. The challenge lies in conveying the right messages, and choosing the appropriate approach, language, and strategy.

Space: Desk research reveals that both indoor and *outdoor* education is taking place in relation to soil (health) education An emphasis is placed on *outdoor* activities that foster the connection to the environment and instil awareness and a sense of holistic living habits. However, interviewees claims that *indoor* education is predominantly embedded while *outdoor* activities are mostly absent: soil (health) education, at the general public level, take place mostly via TV programmes, conferences and at specialized and exclusive spaces, such as fairs and congresses. *Outdoor* education has generally a little public but provides the opportunity for open dialogue and inclusive and participatory learning. The wish is, therefore, to enhance *outdoor* education. Outdoor education should be more encouraged, as it allows learners to engage in more emancipatory and interactive activities, beyond just exhibitions and fairs.

Process: Soil (health) education offers for general public are found to be facilitated predominantly through *instructive* processes while *emancipatory* processes are absent. *Instructive* process is needed in order to foster and explain new and good practices. Lots of how-to materials are both instructive and emancipatory at the same time. The wish is to transition towards higher components of *emancipatory* process.

Activities: According to the desk research, soil (health) education is facilitated by *knowing-based* activities with emphasis on components of *doing* and *being-based* activities. Soil (health) education materials often cannot provide in-depth knowledge but can offer short and concise information, along with examples and how-to to foster awareness and new habits. On the other hand, interviewees claim that little attention is given to *doing* and *being-* based activities. The wish is to facilitate soil (health) education through different *knowing, doing,* and *being-* based activities. Finding the right approach and suitable activities for specific target groups can be challenging because the general public is very diverse, making it difficult to find a common approach.

Paradigm: In desk research, soil (health) education is found to be predominantly focussed on *mechanistic* paradigm while the *ecological* approach is found to be weakly embedded. Interviewees claim that soil (health) education, at the general public level, is shaped mostly by the *mechanistic* paradigm. There is a need for a combined approach that could significantly include community members as soil (health) advocates. The wish is to foster the *ecological* paradigm. This paradigm gives the opportunity to include different perspectives from various stakeholders to foster public dialogue and leading to a more *ecological* view of soil (health). The challenge lies in finding the best format for the general public and securing financing. The involvement of the media can facilitate this approach.

Gaps, challenges & opportunities

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Soil (health) is not a widely recognized topic among the general public in Serbia. The focus of soil (health) education is primarily within the contexts of agriculture, food export, and the mining industry, emphasizing exploitation rather than preservation. The public often lacks awareness of the SDG goals, except when these issues cross global limits and make news, leading to a general perception of these goals as merely political objectives. In Serbia, good practices and values towards the soil and soil (health) are not publicly promoted Additionally, there is a significant gap in media campaigns promoting these practices, particularly in reaching populations encouraging change in values and practices outside of major cities. Key challenges include introducing soil (health) topics as contemporary and urgent issues to the public, and overcoming public reluctance to accept and engage with the concept of SDGs. The slow pace of reforms and the unreliability of institutions further complicate these efforts. Moreover, finding effective formats for public education, securing finances, and choosing the appropriate approach, language, and strategy for conveying messages are significant challenges. Promoting sustainable practices and involving diverse stakeholders such as media, educational facilities, policymakers, NGOs, and community members in a collaborative effort are also challenging. Media campaigns and informal materials can effectively address global and regional soil issues, showcasing good examples and innovative approaches. Implementing outdoor educational activities can foster a connection to the environment and instil holistic living habits. Collaborative efforts among agricultural sector stakeholders, private companies, and teaching facilities can enrich soil (health) education for general public. Emphasizing alternative practices like regenerative agriculture and permaculture can introduce soil (health) knowledge beyond conventional methods. Promoting an ecological paradigm through public dialogue and community involvement can lead to a more ecological education about of soil (health). Additionally, leveraging the media can help in disseminating the right messages and reaching a broader audience.

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A.11. Slovakia

In Slovakia, soil (health) education is undergoing significant trends intending to integrate more comprehensive understanding of soil as an essential environmental component. The vision for soil (health) education is to incorporate soil (health) topics into the different educational levels—ISCED1, ISCED2, and ISCED3 (primary, secondary, and tertiary education levels, respectively)— emphasizing soil's *ecological* and social dimensions. One key impediment to this goal is the outdated curriculum that strongly follows a *mechanistic* paradigm. This leads to a limited understanding of soil's complex role in various ecosystems. There is also a need for professional development opportunities for educators to build their confidence and skills in teaching soil (health) both *indoors* and *outdoors*. Opportunities exist to improve soil (health) education by enhancing the actual educational framework that already connects soil (health) to plant life cycles and ecosystems, which currently only emphasizes its productivity value. Collaboration across disciplines and with external stakeholders, such as farmers, foresters, NGOs, and private companies, could further enrich soil (health) education, offering real-world learning experiences for learners. There is a significant gap in practical, hands-on activities that foster a deeper connection between students and soil (health) (Amador, 2019). Emphasizing soil's cultural and philosophical aspects could enhance public awareness and appreciation of soil's value in sustaining environmental and human health.

Primary education

Vision: to integrate soil (health) education thoroughly into the primary curriculum, emphasizing soil as a vital component of the environment.
Needs: to provide teachers with professional development opportunities to equip them with the necessary skills and confidence to teach soil (health) topics effectively, both indoors and outdoors; attractive and easy-to-understand teaching material
Opportunities: Currently, soil (health) is mentioned only twice in the primary education State educational program. However, it is already linked to the study of plant life cycles and ecosystems in grades one through four. This existing curriculum framework offers a foundation that can be expanded to include more comprehensive content on soil (health), thus broadening students' understanding of its importance and promoting a deeper understanding of environmental science from an early age.

State and wishes of soil (health) education.

Purpose: The main purpose of soil (health)-related education at the primary level is to familiarize students with the concept of soil as a crucial part of the environment, particularly in relation to plants and gardening activities. A review of the science curriculum for primary level, ISCED1, the State educational programme, shows that the soil is mentioned only two times: in connection with the plant life cycle, and as a part of the environment (for the first and the second grade) (State Pedagogical Institute, 2014a). Soil (health) education at the third and the fourth grades of primary education is only treated in connection with field ecosystem and their living conditions for plants and animals (State

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Pedagogical Institute, 2014b). Soil (health) education at primary educational level mainly aligns with Mission Soil objectives of *improving soil structure (to promote biodiversity)*, *reducing soil pollution (and enhancing restoration)*(Pado, 2006), and *improving soil literacy* (Šimonovičová et al., 2013). The educational offers focused on soil, in general, are limited, with no significant connection with soil (health). Soil (health)is only mentioned as a resource that plants need. Most descriptors are vague, , or are not fully integrated: *reducing desertification, conserving soil organic carbon stocks, stopping soil sealing and increasing re-use of urban soil, and reducing the EU global footprint on soils.* In general, the EU Soil Deal mission goals are considered too complex to be integrated into the ISCED 1. Science subjects at the primary education level, which include soil (health) topics, focus mainly on basic concepts and simple descriptions of natural phenomena (State Pedagogical Institute, 2014a, 2014b). However, interviewees from the primary education sector claim that none of the EU Soil Deal Mission goals are addressed or mentioned in soil (health) education at the primary level. The wish is to shape soil (health) education to emphasize more the EU Soil Deal Missiongoals of *reducing soil pollution and enhancing restoration, improving soil structure to enhance soil biodiversity, improving soil literacy in society*. However, adapting state curricula to include comprehensive soil (health) education constitutes a significant challenge to this wish.

> I wish to improve soil literacy in society. Children should learn about soil as part of something bigger; they should understand that nature is made up of various components that interact with each other. We should also improve science education in in-service training for primary school teachers.
> *-A university lecturer (from focus group).*

Educational materials also present how soil (health) contributes to Sustainable Development Goals (SDGs), primarily addressing *Life on Land, Quality Education* (with some topics covered in the curricula) and partly *Zero Hunger* (highlighting soil's role in agriculture), *Life below Water* (State Pedagogical Institute, 2014b). The SDGs that are weakly embedded are *clean water and sanitation, good health and well-being*. The other SDGs, including as *no poverty, gender equality, affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure, reduced inequalities, sustainable cities and communities, responsible consumption and production, climate action, peace, justice and strong institutions,* and *partnership for the goals*, are not embedded . On the other hand, interviewees from the primary education sector claim that none of the SDGs is explicitly treated or mentioned in soil (health) education at the primary level. The wishes are to strengthen the focus on SDGs such as *quality education, sustainable cities and communities, climate action, life on land, good health and well-being,* and *zero hunger*.

A review of elementary school curricula reveals that, in terms of human development, the purpose of soil (health) education is predominantly focused on *knowing* about basic natural phenomena, defining fundamental concepts, and being able to explain simple contexts. This knowledge is directly connected with the outputs and expectations defined in the State Educational Programme. The purpose of *being* which involves developing

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observational and comparative skills and supporting simple exploratory activities partially addressed (State Pedagogical Institute, 2014a, 2014b). The practical aspect, or the purpose of *doing*, which includes enhancing theoretical understanding through practical experience and teaching specific practical skills (such as measurement and observation), is weakly embedded. The challenge is to motivate and engage students, to provide them with skills like communication and teamwork, and to shift from very traditional teaching methods. The wish is to strengthen the purpose of *being* amongst primary school students.

Collaboration: Collaboration in soil (health) education is predominantly *narrow*, and occasionally *narrow-broad*. Educational materials created through collaboration between multiple stakeholders from different sectors and disciplines are scarce. Only a few relevant research outputs, such as those by Balážová, et al. (2023), address ecological literacy of primary school students in Slovakia, pointing on partial inclusion of soil. Additionally, collaboration between teachers across disciplines is often lacking, hindering a comprehensive approach to soil (health)education. Moreover, partnerships with local communities, universities, environmental organizations, and soil science experts are frequently absent. The wish is to expand the collaborations to *narrow-broad*. The challenge is to establish effective and long-term cooperation. Soil (health) is a complex topic: an in-depth- understanding of soil (health) requires the integration of more disciplines such as science, geography, and environmental studies. Engaging stakeholders such as policymakers, educators, and community organizations can provide a valuable resource and opportunity to integrate into primary school curricula more real-world learning experiences in the context of soil (health).

Space: A review of educational materials indicates that soil (health) activities and content in primary schools predominantly are designed to take place *indoors* (mainly in the classroom). *Outdoor* education is not specifically mentioned in the State Educational Programme. Analysing the educational material, challenges for outdoor education are clear. There are limited opportunities for pupils to explore and interact with soil in its natural environment, and there is a lack of necessary resources, such as outdoor learning spaces, gardening tools, and soil testing kits, to facilitate educational activities. Furthermore, some primary teachers may lack the training and confidence to teach effectively about soil (health) outdoors. Additional challenges include limited time allocation, limited curriculum integration, safety concerns, and a lack of soil diversity, which depends on the geographical location of the school. The wish is to emphasize and integrate *outdoor* education for soil (health) topics. Interviewees mention as ideal *outdoor* learning spaces: school gardens, farms, and parks. To shift to more *outdoor* education some strategies are required: professional development for teachers, partnership with local environmental organisations, and integration of *outdoor* learning into the curriculum.

Process: Soil (health) education for primary schools in Slovakia is currently delivered primarily through *instructive* process. The *emancipatory process*, however, is absent from both the curricula and the educational policy documents. The wish is to incorporate the *emancipatory process* when shaping soil (health) education at the primary school level

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in Slovakia. The wish is to shift the focus toward an *emancipatory* processes in soil (health) education. To achieve this, it is vital to integrate more hands-on learning, inquiry-based learning, didactic games, discussions with experts, study trips, and group fieldwork. By adopting an *emancipatory* approach, primary schools can empower students to become informed, critical and environmentally conscious citizens, actively engaged in creating a more sustainable world.

Activities: Soil (heath) education in Slovak primary schools is predominantly facilitated by *knowing-based* activities, focusing on understanding of basic natural phenomena. Activities that emphasize *being* are not mentioned, activities focus mostly on developing observational and comparative abilities while supporting simple exploratory activities. (State Pedagogical Institute, 2014a, 2014b). It seems that *being*-based activities are either unavailable or extremely limited. Additionally, there is a notable absence of art-related activities linked to soil (health) education. Interviewees have highlighted the significant lack of both *being* and *doing- based activities.* The wish is to enhance the inclusion of more *doing- based activities*, such as hands-on learning, in soil (health) education. While these activities are highly beneficial, they can be limited by hygiene regulations, underscoring the need for engaging and feasible classroom settings. Key challenges include the limited use of educational games and role-playing due to a lack of appropriate resources.

Paradigm: A review of soil (health) education resources for primary schools reveals a predominant focus on *mechanistic* paradigm, with little emphasis on the *ecological* paradigm. The wish is to introduce the *ecological* paradigm to foster environmental awareness and help students understand the complexities of ecosystem related to soil (health). However, challenges exist, such as the complexity and abstraction of ecological concepts, which can be difficult for the pupils. Simplifying these concepts without oversimplifying them requires a delicate balance.. Additionally, many primary school teachers lack the necessary training in ecology and environmental science, making them feel uncomfortable or underprepared to teach from an ecological perspective. To address these challenges, collaboration with environmental organizations, universities, and community-based stakeholders could provide valuable support and resources, helping to effectively integrate the ecological paradigm into soil (health) education at the primary school level.

> The State School Educational Programme does not support using an ecological paradigm. The information about the environment is not presented as the whole but as the parts.
> *-A secondary school teacher (from focus group).*

Gaps, challenges & opportunities

In Slovakia, soil (health) education is notably lacking in primary education curricula, leading to significant knowledge gaps as children advance in their education. This underrepresentation in the State Educational Program may contribute to a broader societal unawareness of the crucial role that soil plays in environmental health and sustainability. The complexity of soil (health), with its interdisciplinary nature, makes it

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challenging to simplify for pupils, particularly at the ISCED 1 level (primary education). Despite these difficulties, there is an opportunity to focus on the affective aspects of learning – emphasizing the importance of soil for life, human existence, and the need for its protection. Integrating soil (health) education into primary curricula would require addressing both its scientific and socio-cultural dimensions, thereby enriching student´s understanding and appreciation of this vital resource. Challenges persist, including changes in the State Educational Program and the scarcity of suitable teaching materials and activities for teachers. Currently, Slovakia lacks a dedicated online or resources that provides soil educators with grade-specific concepts, lesson plans, and activities related to soil science, further complicating efforts to improve soil (health) education at the primary level.

Secondary education

Vision: to develop a comprehensive educational framework that includes social, cultural, and philosophical aspects of soil (health) science, thereby preparing students to address real-world environmental challenges
Needs: to implement changes in the State Educational Program to improve soil (health) education
Opportunities: Soil is mostly mentioned as the foundation of terrestrial ecosystems. Teaching about soil (health) roles in these areas offers a unique way to integrate chemistry, physics, biology, and geology (STEM). The multifaceted roles that soil has played in human interactions with the environment represent an opportunity to teach history and anthropology through the lens of soil. By examining how soil has influenced human development, agriculture, and cultural practices, educators can provide students with a deeper understanding of both the scientific and social dimensions of soil, making it a rich subject for cross-disciplinary learning.

State and wishes of soil (health) education.

Purpose: The Slovakian state educational programme for the secondary level clearly shows the approach through which soil (health) is taught. Soil (health) is mentioned in subjects' curricula such as "Biology" and "Technique" (this subject focuses on practical, everyday activities). In biology, soil (health)--related education is mainly connected with soil protection and soil pollution. Soil (health) is introduced as a vital part of the environment, connected to other ecosystems and organisms (plants, animals, and humans). A different approach is used for the topics related to the "Technique" subject, where soil (health) is mentioned in connection to gardening, plant production, soil maintenance (State Pedagogical Institute (2014c); State Pedagogical Institute (2014d)). Soil (health) education at secondary level address several Mission Soil objectives including- *reducing soil pollution and enhancing restoration, preventing erosion, improving soil structure (to enhance soil biodiversity)*, where improving the soil structure aims at making soil suitable for gardening and plant production, *improving soil literacy* and *conserving soil organic carbon stocks.* The wish it to strengthen *conserving soil organic carbon stock, reducing*

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soil pollution and enhancing restoration, and *improving soil structure to enhance soil biodiversity.*

Secondary level teaching materials also present the connections between soil (health) and certain SDGs, specifically *life on land, quality education* and to some degree *zero hunger* (by presenting the importance of soil (health) for plants in agriculture), and *life below water*, however these are not directly linked State Pedagogical Institute (2014c): Interviewees underline the connection between soil (health) education and the SDGs of *no poverty, zero hunger, good health and well-being, clean water and sanitation, life below water, life on land, life on land,* and *partnership for the goals.* The wish is to embed more the SDGs of *no poverty, zero hunger, good health and well-being, clean water and sanitation, life below water, life on land, climate action, and partnerships for the goals.*

In terms of human development, soil (health) education is predominantly focused on *knowing* and *doing*. In "Biology", the focus is to understand basic concepts in connection with organisms and their environment. In the "Technique", the focus is, for instance on developing the knowledge and practical skills related to garden work (to produce fruits and vegetables). *Doing* is mostly embedded in the context of soil cultivation (soil processing: raking, shovelling, bed preparation, increasing of fertility (fertilization), crop rotation, plant nutrition, plant protection) (State pedagogical institute 2014c, 2014d! The descriptor "being" is absent, even in the State educational program. The wish is to embed *being* as human development purpose in soil (health) education at secondary level.

Collaboration: Collaboration in soil (health) education at secondary level in Slovakia varies from *narrow* to *narrow-broad.* The collaboration takes place, occasionally, at an interdisciplinary level, but it is never intersectoral: soil (health) content is presented from different disciplines 'perspectives in connection with agriculture and crop (e.g., vegetables and fruits)production. However, the connection and collaboration with sustainability subjects is scarce (State Pedagogical Institute (2014c, 2014d): The descriptor broad is missing at the secondar level of education. The wish is to have a *narrow-broad* collaboration. However, establishing effective and long-term collaboration is recognized as challenging.

Space: A review of educational materials indicates that soil (health) education in secondary schools predominantly occurs both *indoors* and *outdoors*. For the "Biology" subjects, soil (health) education is facilitated through both *indoor* and *outdoor* activities, such as monitoring the pollution and quality of soils close to the schools; whereas soil (health) education included in "Technique" subjects are mainly conducted *outdoor* through activities such as gardening and cultivation (plant production). Interviews, on the contrary, reveal that *outdoor* activities are missing in soil (health) education at the secondary level. The wish is to strengthen *outdoor* education and make soil (health) education take place in school gardens, farms, and parks. This approach would not only enrich the educational experience but also foster a deeper connection between students and the environment.

Process: Revision of the official curricular documents (State Pedagogical Institute 2014c, 2014d) for secondary education reveals that soil(health) education is predominantly

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facilitated by *instructive* processes. At the secondary level of education, there is pressure to prioritize the coverage of content directly mentioned in the curricula. Consequently, there is a significant lack of time for inquiry-based and *emancipatory* learning approaches. The wish is to facilitate soil (health) education through an *emancipatory* approach and activities such as didactic games, discussions with experts, study trips, and group field work.

Activities: In Secondary education, soil (heath) education is facilitated by both *knowing-based* activities and *doing-based* activities. In the Slovakian curricular documents (State Pedagogical Institute 2014c, 2014d), the *being-based activities* are not mentioned at all. On the other hand, interviews underline the absence of both *doing-based* activities and *being-based activities.* The wish is to incorporate substantially *doing-based activities*, such as educational games, and role-playing activities, in soil (health) education. However, the challenge is not only due to the lack of suitable activities but also the use and implementation of existing ones.

Paradigm: A review of soil (health) education literature and official state documents for secondary schools indicates both *mechanistic* and *ecological* paradigms. The wish is to shape soil(health) education, at the secondary level, through an *ecological* paradigm. However, shifting towards an *ecological* approach, both in adapting the state educational program accordingly and in finding suitable educational activities for teachers, is challenging. Secondary education systems, in Slovakia, often compartmentalize subjects into distinct disciplinary domains, such as biology, chemistry, geography, and agriculture. This specialization can create silos, making it challenging to adopt an *ecological* paradigm that emphasizes the interconnectedness of various ecological systems and the integration of multiple disciplines.

Gaps, challenges & opportunities

During last few decades, several papers have pointed out that soil science has been overlooked in primary and secondary education (Bridgesand Van Baren, 1997, Diochon et al., 2017, Breivik er al., 2022). The main challenge in enhancing soil (health) education at the secondary level in Slovakia is incorporating necessary changes into the State Educational Programme. Without policy support, it would be almost impossible to make significant improvements in soil (health) education and incorporate necessary changes. Integrating Sustainable Development Goals (SDGs) into the existing curricula while aligning them with academic standards and learning objectives adds complexity. Curriculum developers and educators may struggle to balance core subjects with the broad themes of the SDGs.

In soil (health) education, fostering intersectoral and interdisciplinary types of collaboration is another challenge. The Slovak secondary education system tends to compartmentalize subjects, making it difficult for teachers to connect different disciplines like biology, chemistry, geography, and techniques. . Teachers may feel more comfortable teaching within their disciplinary expertise and lack the necessary skills or support to collaborate with colleagues from other subject areas. This separation can hinder a more comprehensive soil (health) education that furthermore requires hands-on exploration, critical thinking, and

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reflection, often sidelined in favor of traditional, memorization-based teaching methods and exam preparation. Moreover, national curriculum standards dictate the content and sequence of topics to be covered, leaving few possibilities for incorporating emancipatory pedagogies that encourage students to challenge dominant narratives and engage in critical dialogue about soil (health)-related issues. Activities in soil (health) education prioritize content and standardized learning outcomes, leading to a focus on delivering information through traditional classroom instruction and textbook-based learning. This overshadows the importance of experiential learning and being-based activities, such as mindfulness exercises, reflective practices, and special outdoor experiences, which can deepen students' connection with nature and soil.
Finally, soil is mostly mentioned as the foundation of terrestrial ecosystems. Integrating the roles of soil (health) in these areas provides a unique way to connect both STEM (science, technology, engineering, and math) education and non-STEM subjects (e.g., history, ethnology, anthropology). The multifaceted roles that soil has played in human interactions with the environment additionally represent an opportunity to teach history and anthropology through the lens of soil. Soil can be presented as multidimensional and influenced by many factors, such as geography, ecology, agriculture, chemistry, and even social sciences. In Slovakia, there is lack of publicly available and easily understandable resources (e.g. a website or portal) to support educators with comprehensive information on soil (health).. As a result, resources for developing grade-specific concepts, lesson plans, and classroom activities are also lacking. Finally, soil (health) education should consider social, cultural, and even philosophical aspects of soil science. Understanding these aspects enriches the educational experience by connecting soil science to broader societal values and human experiences. Social and cultural considerations help contextualize soil issues within local traditions and practices, making the subject more relevant and engaging to diverse audiences.

Tertiary education

Vision: to foster a deeper understanding of the complexity of soil (health) and its relevance through a more interdisciplinary approach
Needs: To incorporate both ecological and social dimensions of soil (health) into university courses across various disciplines.
Opportunities: Field-based courses, trips and excursions offer students the opportunity to study soil (health). Engaging directly with soil in natural settings allows students to apply classroom knowledge in the real-world context. For instance, the Bachelor study program 'Protection and Restoration of Environment' at the University of SS. Cyril and Methodius in Trnava includes practical components such as Field Research I and II, and the 'Save the Wetlands' project, which involves hands-on learning and fieldwork in wetlands. At Comenius University in Bratislava, students engage in site visits to contaminated areas as part of the Phytoremediation subject, typically conducted in the summer semester.

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State and wishes of soil (health) education.

Purpose: At the tertiary level, in Slovakia, educational materials address Mission Soil objectives of *reducing desertification, conserving soil organic carbon stocks, stop soil sealing and increasing re-use of urban soil, reducing soil pollution and enhancing restoration, preventing erosion, improving soil structure to enhance soil biodiversity,* and *reducing the global footprint on soil*, depending on the different study programmes' focus. The goals of *stopping soil sealing and improving soil literacy in society* were found weakly embedded in the courses reviewed in this research. On the other hand, interviews reveal that soil(health) education, at the tertiary level, focuses on *improving soil literacy in society* and, instead neglects *reducing desertification, conserving soil organic carbon stocks, stopping soil sealing and increasing re-use of urban soils, preventing erosion, improving soil structure to enhance soil biodiversity,* and *reducing the eu global footprint on soils*. Overall, incorporating soil (health) education into tertiary-level curricula, especially in social science programmes, , and enhancing EU soil deal mission goals that do not only address the "use of soil" seem to be the main challenges. Arousing students' interests in soil and its protection is also fundamental for reaching these goals. The wish is to integrate the EU soil deal mission goals of *reducing the eu global footprint on soil, improving soil structure to enhance soil biodiversity,* and *reducing desertification.*

The educational materials also address the SDGs of *clean water and sanitation, affordable and clean energy, industry, innovation and infrastructure, sustainable cities and communities, responsible consumption and production, climate action, life below water, and life on land.* These SDGs vary in their connection with current soil (health) education at the tertiary level and are not effectively incorporated into the curriculum. Broader SDGs, especially those that primarily address socio-economic issues such as , *zero hunger, good health and well-being, quality education, decent work and economic growth, reduced inequalities,* weakly embedded. The absent SDGs are *gender equality, no poverty, peace, justice and strong institutions and partnerships for the goals*. However, interviews reveal that the SDGs of *zero hunger and good health and well-being* are predominantly embedded. The wishes are to broaden the scope of soil (health) education towards the SDGs of *no poverty, clean water and sanitation, sustainable cities and communities, responsible consumption and production, zero hunger,* and *responsible consumption and production.*

In terms of human development, the purpose of tertiary soil (health) education is predominantly on knowledge acquisition (*knowing*) while *doing*-based purpose represents a small component. In Slovakia, university courses focus mainly on transmitting knowledge, and activities are relatively less connected to the *being*, which seems to be missing in the shaping of soil (health) education. The wish is to incorporate the three elements of *knowing, doing,* and *being* when defining soil (health) education at the tertiary level. These approaches should be combined to shape a soil (health) education that fosters sustainable uses of soil.

Collaboration: In Slovakia, tertiary education includes both general and specialized institutions. General universities offer a broad range of programs in areas like education,

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arts, sciences, and technology. Specialized institutions, such as the Slovak University of Agriculture in Nitra and the Technical University in Zvolen, focus on specific fields. The Slovak University of Agriculture covers agrobiology, sustainable agriculture, food technology, and rural development, while the Technical University in Zvolen specializes in forestry, wood science, and environmental studies. Soil (health) education at the tertiary level primarily involves *narrow* collaborations, occasionally extending to *narrow-broad* collaborations in more specialized universities. In these institutions, external stakeholders and educational actors are more interconnected, and students often have the opportunity to learn from companies or farmers alongside their peers and teachers. However, Slovakia lacks universities of applied sciences, which typically promote extensive collaboration among various sectors, including offices, companies, NGOs, and academic institutions. The existing ones are based on personal contacts of educators and are based on research projects supported by mainly national grants. As a result, such *broad* collaboration in soil (health) education is limited at the tertiary level. Interviews underline that *narrow-broad* forms of collaboration take place occasionally.There is a notable wish to establish more comprehensive forms of collaboration, integrating diverse sectors and scientific disciplines, particularly involving the third sector. The main challenge remains fostering long-term partnerships with soil (health) advocates and nature protection NGOs to enhance courses focused on soil conservation.

Space: Teaching materials are tailored for both *indoor* and *outdoor* education, although the former is applied more often. Supporting *outdoor* education at the tertiary level can provide students with hands-on learning experiences (e.g. Feszterova, Jomova, 2015) that deepen their understanding of soil systems and foster a connection to the natural environment. For instance, the Bachelor study program "Protection and Restoration of Environment" at the University of SS. Cyril and Methodius in Trnava includes practical components such as Field Research I and II, and the "Save the Wetlands" project (Projekt SWT :: Ekokatedra, 29/08/2024), which involves hands-on learning and fieldwork in wetlands. At Comenius University in Bratislava, students engage in site visits to contaminated areas as part of the Phytoremediation subject, both typically conducted in the summer semester. The wish is to further foster *outdoor* activities to facilitate soil (health) education at the tertiary level. In order to do so, tertiary level interviewees suggest significant change in study plans but also the introduction of specific educational approaches. Field-based courses and field trips offer students the opportunity to study soil (health) directly in natural environments and in contact with local farms, forests, wetlands or specific research sites, allowing students to apply classroom knowledge in the real-world context and develop a deeper appreciation for the complexity of soil systems. In outdoor laboratories and demonstration sites on campus or in nearby locations students can engage in soil (health) research and experimentation.

Process: Based on the review of course modules for tertiary level soil (health) education in Slovakia, there is an apparent predominance of *instructive* processes based on the use of

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traditional lecture-based model. The *emancipatory* process is weakly embedded in soil (health) education at tertiary level. However, there is a growing recognition of the importance of more interactive and student-centred approaches of teaching and learning. The wish is, indeed, to foster a more *emancipatory* approach when shaping soil (health) education including active-learning and problem-based learning that can enhance students' engagement and critical thinking skills.

Activities: At the tertiary level, soil (health) education combines *knowing-based* with minor components of *doing-based* activities. At the tertiary level, students are usually evaluated according to the level of their theoretical knowledge. University courses related to soil (health) education often include components of hands-on learning, such as experiments, projects, simulations, fieldwork, and practical exercises. These activities are primarily connected to fieldwork and laboratory work and are often a part of thesis research. *Being-based* activities are absent from most courses. The integration of *being-based* activities would require reshaping soil (health) education and increasing the involvement of external stakeholders, such as NGOs and artists, who could advocate for alternative educational approaches and promote a more comprehensive understanding of soil (health) and its value. The wish is to incorporate more *doing-based* activities in soil (health) education. However, this type of activities is often "time-consuming" and are not yet and adequately proven to be effective and advantageous for the educational process.

Paradigm: In tertiary level both *mechanistic* and *ecological* paradigms are used to design soil (health) education. *Ecological* paradigm predominantly shapes environmental-related study programs while technology, engineering, geology, and agriculture subjects are mainly shaped by the *mechanistic* paradigm. However, university disciplinary specialization creates silos, making it challenging to adopt an *ecological* paradigm that emphasizes the interconnectedness of various ecological systems and the integration of multiple disciplines. For example, agricultural disciplines tend to focus on soil (health) primarily in terms of plant production, with little exploration of the broader ecological functions of soil within the ecosystem, the idea of sustainability is still very rare (Kaletová et al., 2022). Interviews emphasise this challenge and describe a soil (health) education in which the *mechanistic* approach dominates. The wish is to shape soil (health) education through the *ecological* paradigm that fosters a deeper understanding of soil as part of an extended and interconnected system.

Gaps, challenges & opportunities

In Slovakia, there is a growing need to raise awareness and promote a comprehensive soil science perspective—one that considers soil's physical, chemical, and biological properties, as well as its processes and roles within ecosystems.Yet, enrollment and graduation rates of soil science students in university undergraduate and graduate programs are declining. This trend is also noticed in natural science disciplines in general. This decline has been partly attributed to a lack of public awareness of soil (health) and its value to society. Furthermore, the connection between natural sciences and social sciences (including the arts) and soil is

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missing. Usually, soil (health) is perceived only as a natural science topic, primarily taught within disciplines such as biology, environmental science, and agriculture. Consequently, limited attention may be given to the social dimensions of soil (health), such as land use practices, environmental justice, and cultural perceptions of soil within social science curricula at universities. In fact, there is a gap in incorporating the Sustainable Development Goals (SDGs), especially those related to social and economic sustainability, into soil-related subjects and study programs at universities. However, at the tertiary level, it is crucial to foster a comprehensive understanding of the connections between soil (health), human well-being, and economic prosperity. According to Harteminkand, Mc Bratney (2008), to improve soil science education at tertiary level, curriculum development should evolve as the soil science disciplines involves and encompasses new fields of study. Several factors challenge this integration into soil (health) education: curriculum and design priorities that are developed based on traditional disciplinary boundaries do not incorporate interdisciplinary perspectives. Resource constraints, such as the need for investments in faculty training, curriculum development, and instructional materials, make it challenging to implement curriculum revisions that incorporate social sustainability.
Exposing students to diverse disciplinary approaches, through interdisciplinary courses and programs (Zhuang et al., 2015), can foster a deeper understanding of the complexity of soil (health) and its relevance. Engaging in hands-on research and problem-solving activities allows students to gain interdisciplinary skills while contributing to real-world solutions to soil (health) challenges. By incorporating outdoor education, universities can enrich soil (health) education and inspire a sense of curiosity and empowerment in students, encouraging them to become effective advocates for soil (health) and sustainability. Teacher preparation, the availability of suitable areas for outdoor soil (health) education, the integration of such activities into the curriculum, and the development of appropriate evaluation systems are obstacles to fulfilling this wish. University education is often dominated by lectures where students listen passively, and examinations are organized to assess passive knowledge. This approach focuses on repeating theory without encouraging a deeper understanding or the ability to apply knowledge practically. The way soil (health) education is conducted at university need to be challenged to foster a deeper connection between learners and soil (health).

Vocational educational training (VET)

Vision: to integrate comprehensive knowledge and experiential learning that aligns with Mission Soil objectives and SDGs, preparing students to address soil (health) challenges.
Needs: to update outdated VET curricula to incorporate systems-based approaches, *outdoor* experiential learning, broader stakeholder collaboration, and an *ecological* paradigm that fosters critical thinking and practical skills.
Opportunities: Existing collaborations with farmers and potential employers provide students with practical experiences, which can be expanded to further enhance hands-on learning.

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State and wishes of soil (health) education.

Purpose: At the Vocational educational training level (VET), soil (health) education apparently focusses on providing the basic knowledge and on improving students' soil-related skills. These materials address the Mission Soil objectives of *preventing erosion, improving soil structure to enhance soil biodiversity* (but in this case exclusively to agriculture productivity). On the other hand, interviewees claim that the purpose of soil (health) education is also to *improving soil literacy in society* and *reducing soil pollution and enhancing restoration*. However, these goals are found to be weakly embedded or not embedded at all in the educational materials reviewed. The wish is to incorporate Mission Soil objectives of *conserving soil organic carbon stocks and stopping soil sealing and increase re-use of urban soils* into the purpose of soil (health) education at VET level. The educational materials on soil (health) at VET level, present the connections of soil (health) with SDGs of *life below water, life on land*, *responsible consumption and production, and climate action*. Broader SDGs especially those that primarily seem to address socio-economic issues are absent. The actual VET curriculum is outdated and not adequate connection between SDGs is provided. In Slovakia, secondary vocational education and training (VET) institutions that align with specific Sustainable Development Goals (SDGs), particularly those related to sustainable agriculture and zero hunger, clean water and sanitation, climate action, and life on land (SDG 15), have the potential to more easily incorporate modules on soil and soil (health) into their curricula. The wishes are to make the connections between soil (health) and all SDGs more explicit within relevant VET courses, with a special emphasis on *no poverty, quality education, gender equality, clean water and sanitation*.

In terms of human development, the purpose of VET level soil (health) education is predominantly on knowledge acquisition (*knowing*) with an assumption that knowledge will create the foundation for systems thinking and *doing,* that is less embedded. The purpose of *being* is largely absent from the curricula. The wish is to incorporate all the three elements of human development when shaping the purpose of soil (health) education. Developing *Being* and fostering values in relation to soil (health) is considered the main challenge.

Collaboration: Soil (health) education at the VET level primarily involves *narrow* collaborations, occasionally extending to *narrow-broad* collaborations. VET institutions connect with external stakeholders (farmers, future employers… etc.) to provide students with practical and internship experiences. *Broad* collaborations are absent. Involving a wider range of stakeholders and sectors is seen as important for guiding students towards sustainability practices and jobs. However, updating the curricula while maintaining the teaching of core subjects is necessary. The wish is to foster *narrow-broad* forms of collaboration, mostly between different sectors and scientific areas.

Space: Most soil (health) education related VET programs are designed to take place both *indoors* and *outdoors*. However, there is a preference for *indoor* education even though soil (health) education can offer interesting and valuable activities *outdoor*. The research, observation and investigation are planned mainly inside the laboratories. Various

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challenges that hinder *outdoor* education at VET include limited access to outdoor learning spaces (such as agricultural fields, forests, wetlands, and brownfields) for conducting hands-on soil (health) - related activities, safety and liability concerns (inherent risks or exposure to environmental hazards) and equipment use. VET institutions struggle, furthermore, with integrating soil (health) *outdoor* activities into the curriculum and assessment system: constraints related to scheduling, academic requirements, limited time and resources and alignment with learning outcomes challenge this integration. The wish is to enhance *outdoor* education by identifying suitable soil (health) activities that can be conducted in forests or on farms.

Process: Soil (health) curricula at VET are facilitated mainly through an *instructive* process. *Emancipatory* processes are absent. The wish is to facilitate soil (health) education through the *emancipatory* approach, even though this approach faces a few challenges. VET institutions may struggle to navigate power dynamics between instructions and learners, as well as institutional hierarchies that can inhibit participatory decision-making. VET instructors may lack training and support in implementing "learning by doing" and *emancipatory* approaches: this shift requires a collaborative approach that involves educators, administrators, policymakers, and community members. VET institutions have the opportunity, through the *emancipatory* approach, to shift towards transformative learning experiences, empowering learners to become agents of change.

Activities: At VET level, soil (health) education combines *knowing-based* with minor components of *doing-based* activities. *Being-based* activities are absent from most soil (health) courses, at VET level. The wish is to facilitate soil (health) subjects mainly through *doing-based* activities and to embrace experiential learning, with more fieldwork and closer cooperation with farmers and representatives of NGOs involved in soil protection. However, while hands-on activities are more difficult to implement, they offer valuable opportunities to better prepare students for careers in agriculture, environmental science, and related fields.

Paradigm: In VET programs related to soil (health) education *mechanistic* paradigm dominates. *Ecological paradigm* is weakly embedded. The wish is to shape soil (health) education, at VET level, through the *ecological* paradigm to equips students with a deeper understanding of the complex and interconnected soil(health) system.

Gaps, challenges & opportunities

In Slovakia, the latest content revision of the State Educational Programs seem was completed in 2013. For more than decade, there have been no significant changes in the state curriculum of VET education. This is significant and as it is clear, from the above research, that VET curricula in soil (health) education needs a renewal and shift from its traditional and *instructive* approaches. Furthermore, it is important to ensure that VET graduates are well-prepared to meet the demands of employers and contribute effectively to the workforce in soil (health) sectors such as agriculture, horticulture, forestry,

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environmental management, and landscaping. VET needs to offer learners a pathway to diverse and rewarding careers in fields related to soil science and management, by enhancing soil (health) education through experiential learning and interdisciplinary approaches. A shift towards *broader* forms of collaboration and towards outdoor education is clearly wished. VET institutions can enhance the quality and effectiveness of *outdoor* soil (health) education and better prepare students for careers in agriculture, environmental science, and related fields. There is a need to invest in *outdoor* learning infrastructure, develop safety guidelines and protocols, foster partnerships with local organizations and landowners, integrate *outdoor* learning into curriculum design, and explore alternative assessment methods that recognize and value experiential learning and *doing-based* activities. Fostering collaborations between universities and agricultural or environmental organizations for joint research projects is crucial. Students can be involved in these projects, contributing to and learning from cutting-edge research that addresses practical challenges faced by farmers and land managers. Engaging students in developing innovative solutions to problems identified by collaborators is also important. This could include creating new soil management technologies, improving sustainable farming practices, or addressing soil degradation issues Educational processes and content should be highly relevant to modern methods and innovations in practice, such as sustainable soil management practices, soil conservation techniques, agroecology, organic farming, and climate-smart agriculture. Implementing the *ecological* paradigm for soil (health) education is challenged by the limited integration of systems-based approaches into the curriculum. Limitations include dominant reductionist paradigm, practical implementation, and disciplinary silos. In fact, VET programs are organized into disciplinary silos, focusing on specific areas of study, such as agriculture and horticulture.

General public

Vision: To integrate all EU Soil Deal mission goals and promote sustainable practices by emphasizing soil's complexities and its role in ecosystem services.
Needs: To encompass broader SDGs and promote a deeper sense of empowerment and stewardship, emphasizing the "*being*" aspect in learning.
Opportunities: No clear opportunities for realising the vision could be found due to lack of available information.

State and wishes of soil (health) education.

Purpose: Educational materials on soil (health) topics are available to the general public mainly in relation to EU Soil Deal mission of *preventing erosion* and *reducing soil pollution and enhancing restoration*. Interviewees from NGO emphasize the importance of incorporating all goals when designing soil (health) education. However, they also claim that society today predominantly focuses on soil (health) in relation to

> The public should know the truth about the current state of the environment (and soil), sometimes we should scare them using the facts, it can support the changes in their lifestyles and decrease consumption.
> *-An NGO Representative (from focus group)*

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consumption, with little emphasis on shifting to more sustainable (soil (health) practices and ways of living. The wish is to integrate all the EU Soil Deal mission goals into the future soil (health) education addressing the general public.

Education material, targeting the general public focus mainly on the SDGs of *life on land*. Interviewees underline the importance of all the SDGs in relation to soil (health) education but underlines the connection with SDGs of *zero hunger*, *good health and well-being*, and *responsible consumption and production.* Broader SDGs, especially those that primarily seem to address socio-economic issues, are weakly embedded: for example, *quality education, gender equality, clean water and sanitation, affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure, reduce inequalities, sustainable cities and communities, climate action, life below water, peace, justice, and strong institutions, and partnership for goals.* Generally educational material for the is not strictly connected to soil (health). Integrating soil (health) education into broader sustainability initiatives and promoting collaboration across sectors, can advance progress towards the SDGs and ensure the long-term health and resilience of soils. Therefore, the wish is to strengthen the goals of *zero hunger, good health and wellbeing, clean water and sanitation,* and *climate action* and to change in this direction the educational approach.

In terms of human development, the purpose of soil (health) education for general public is predominantly on knowledge acquisition (*knowing*), while *doing* purpose is weakly embedded in this educational level. The purpose of *being* is largely absent. To enhance *knowing* and *doing* aspects of soil (health) education, the general public needs to be inspired with a sense of empowerment and stewardship of the land, promoting sustainable soil (health) management practices. However, there is not enough knowledge or opportunity to present and teach about soil (health) in an engaging way to the general public. The wish is to emphasize the *being* when designing soil (health) education, while still including the *knowing* and the *doing*, as interconnected and fundamental elements. Soil (health) education needs to support personal development, inspire values concerning soi protection and to strengthen human-nature relationships.

Collaboration: The soil (health) related education for the general public is predominantly offered through *narrow* collaborations. *Narrow-broad* forms of collaboration are weakly embedded. Occasionally, collaborations occur between two or three sectors, allowing learners to be involved in specific projects. These collaborations can include partnerships between academic disciplines, such as soil sciences and environmental sciences, as well as between NGOs and universities. *Broad* collaborations are absent in the general public level. The wish is to make the collaborations *broad* with engagement of diverse stakeholders and discipline for mutual learning in soil (health) education. This type of collaboration can strongly emphasise soil (health) importance form different points of view.

Space: Educational resources available to general public are designed for both *indoor* and *outdoor* learning. Interviewees, however, claim that there are no real opportunities for *outdoor* soil (health) education. Soil (health) education, according to some general

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public representatives, takes place *indoor* and mainly in school classes, laboratories, and museums. The wish is to bring soil (health) education *outdoor*, and conduct education activities in gardens, farms or forests.

Process: Soil (health) awareness offers for the general public are predominately facilitated through *instructive* processes. *Emancipatory* processes are missing in soil (health) education facilitation. The wish is to facilitate soil (health) education for the general public through a combination of *instructive* and *emancipatory* processes.

Activities: In soil (health) awareness offers for general public, the *knowing- based* activities prevail focusing mainly on the transmission of information. *Doing-based activities* are weakly embedded while *being-based activities* are found to be absent. COPs have emphasized the wish for an integrated approach that incorporates all three components: *knowing, doing, and being- based* activities..

Paradigm: A review of available soil (health) awareness offers for the general public indicates a predominance of both *mechanistic* and *ecological* paradigms. However, interviews reveal that the *ecological paradigm* is weakly embedded. The predominance of the *ecological paradigm* is wished for soil (health) education for the general public. However, how to embed the *ecological* paradigm in soil (health) education for the general public is still unexplored and challenging due to the heterogeneous nature of the group, with its varying knowledge and experiences.

Gaps, challenges & opportunities

Soil (health) education for the general public faces several gaps and challenges. First, there is a general lack of awareness (Urbańska et al., 2022), as many people are unaware of the importance of soil (health) and its impact on food security, biodiversity, and climate change (Breivik et al., 2020). Soil (health) education should underline soil complexities and their role in other ecosystem services. The general public should be informed about the latest research findings and ways to live more sustainably. Access to available and reliable information is limited, as well as educational material that fosters soil (health) sustainable practices. When limited educational material is available and accessible, it often is not targeted and understandable for the general public due to different levels of knowledge and experiences. This is due also to the complexity of soil science and the interconnectedness of soil (health) with other ecosystems. However, this needs to be transmitted.

Outdoor education, although wished, faces several challenges: limited access to *outdoor* spaces, lack of designed hands-on- experiences, weather- depend on activities, accessibility barriers and resources constrains. Furthermore, involving various external actors s both wished and challenging. Involving various stakeholders and external actors with strong position in Slovak society can significantly enrich the educational experience and foster broader community engagement. Involvement of churches, for instance, can support educational initiatives through community outreach programs, sermons, and events that emphasize the importance of soil (health) and environmental stewardship. Local farms, conservation groups, and universities can offer field trips, hands-on experiences, and expert talks that bring theoretical knowledge to life. Further, organizations like Greenpeace Slovakia

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or regional/local environmental groups/NGOs can provide educational materials, workshops, and volunteer opportunities related to soil (health) and conservation. Regional and local governments can also support such activities, for instance, by utilizing participatory budgeting.On the other hand, the always-increasing urbanization disconnects people from the land and agriculture, and therefore from nature and soil value. Behavioural change, as encouraging people to adopt soil-friendly practices, can be challenging. Cultural and societal factors, where cultural attitudes and societal norms may influence perceptions and practices related to soil (health), also play a role. Finally, the absence of supportive policies or regulatory frameworks for sustainable soil management can hinder efforts to promote soil (health) education.

How to use the emancipatory process for the general public is still unexplored and challenging due to the heterogeneous nature of the group, with its varying knowledge and experiences. All in all, both *instructive* and *emancipatory* processes require adopting learner-centred approaches that prioritize active engagement, critical thinking, and empowerment. Integrating participatory methods, experiential learning opportunities, and interdisciplinary perspectives can enhance the effectiveness and relevance of soil (health) education for the general public. By empowering individuals to become agents of change in their communities, soil (health) education can promote more sustainable and equitable soil management practices.

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A.12. Sweden

Soil (health) education in Sweden shows both similarities and differences in terms of the contents, and educational design across various educational levels. At the primary level, the curriculum primarily emphasizes basic soil composition and properties through a mix of *indoor and outdoor instructive* methods. Given the absence of explicit mention of soil (health) in the curriculum, the concept appears unfamiliar to some teachers. Secondary education sees a slight shift towards integrating global issues, where connections to the EU Mission Soil objectives are not explicit but the SDGs are frequently mentioned. Yet soil (health) remains narrowly focused, and predominantly through *knowing*-based activities and limited *outdoor* engagement. Tertiary and VET education levels show a deeper exploration of soil complexities, incorporating both *instructive* and *emancipatory* approaches to enhance students' understanding. While *mechanistic* paradigm dominates at all educational levels, there is wish to increase the *ecological* perspectives and expand more experiential *outdoor* learning opportunities. Nevertheless, at all educational levels, challenges remain regarding the integration of soil (health) into the curriculum, compounded by resource constraints. There is also a recognized need for wider collaboration to enhance soil (health) education.

> I've never heard of it [soil health] before but it's a fun concept to maybe introduce. ...it makes you think a little about soil , what it is and why it's important and so on, but it's the first time I've heard it.
> *-A primary teacher (from focus group).*

> You need to integrate it (soil (health)) into something with a clear reference to the (national) curriculum, which currently does not mention soil (health).
> *-Civil society representative (from interviews)*

Looking ahead, there is a clear wish in Sweden to embed soil (health) education across all educational levels. This includes revising primary and secondary curricula to explicitly incorporate soil (health) topics aligned with SDGs and the EU Mission Soil, and integrating both *mechanistic* and *ecological* paradigms to deepen students' understanding. Emphasizing *outdoor* experiences and doing-based learning is desired to foster hands-on engagement with soil. Strengthening collaboration efforts, particularly with diverse stakeholders such as environmental actors and local communities, aims to enrich educational content and ensure relevance to real-world challenges. Furthermore, addressing resource constraints through increased funding for soil-related activities and providing professional development opportunities for educators are essential steps towards achieving comprehensive soil (health) education in Sweden.

Primary education

Vision: To increase awareness about the crucial role of soil (health) in ecosystems and human well-being.
Needs: To embed soil (health) in national curriculum and offer resources and training to teachers for integrating soil (health) into the curriculum effectively.

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Opportunities: recognition of the importance of collegial learning and collaboration among teachers, as well as the encouragement for transdisciplinary education in Swedish school policy offers an opportunity to adopt a multidisciplinary approach to soil (health) education within the context of existing curriculum topics.

State and wishes of soil (health) education

Purpose: Primary schools in Sweden follow a national curriculum developed by the Swedish Agency for Education (Swedish: Skolverket) (Skolverket, 2022). Soil (health) is not explicitly mentioned in this curriculum. Consequently, textbooks only briefly touch on soil (health) related issues in subjects like geography, biology and sustainability (e.g. Persson, 2023; Svenska Kunskapsförlaget, 2023). Furthermore, At the primary level, soil (health) related teaching focuses generically on soil composition and properties. Consequently, connections between soil (health), the Mission Soil objectives, and the SDGs are generally absent, with only a few goals mentioned. For instance, the biology course for grades 1–3, developed by Naturvetenskap och teknik för alla (Science and Technology for All), supports over 60% of Swedish municipalities. This course primarily describes basic soil composition and properties and therefore addresses *improving soil structure to enhance biodiversity* without broader contextual references (Naturvetenskap och teknik för alla, 2018). Another example is the mention of erosion (*preventing erosion*) in connection to the natural agents of erosion namely wind, water and ice in a geography textbook (Haraldsson, Karlsson & Molin, 2017). Examples that include the connections with the SDGs include teaching on soil structure as a foundation for *life on land* (Naturvetenskap och teknik för alla, 2018), the impact of soil and fertilizer runoff on *clean water and sanitation* and *life in water* (Persson, 2023), and the effects of mangrove deforestation on *life in water* (Haraldsson, Karlsson & Molin, 2017). The connection between soil (health) and other SDGs and EU mission goals are missing. While there was no clear wish in terms of specific descriptors that should be strengthened, the general wish is to increase the awareness that soil is a finite resource that is fundamental for our survival.

In terms of human development, the curriculum and the textbooks indicate that purpose of soil (health) education is predominantly *Knowing*. However, the insights gained from the CoP indicated that practical (*doing*) exercises both in formal (e.g. NTA, 2018) and non-formal courses (e.g. Experimentarkivet, 2023; LRF Sveriges Bönder, 2023), these exercises however, often serve to demonstrate, or initiate reflections and discussions on factual knowledge. The purpose of *being* is largely absent. The wish is to incorporate all three purposes to soil (health) education—*knowing, doing* and *being*.

Collaboration: Soil (health) education in primary schools in Sweden is predominantly *narrow* and primarily involves students and teachers. However, there are initiatives that encourage joint educational activities of parents and children such as a website with collection of soil experiments (Experimentarkivet, 2023). There are also resources that encourage joint educational activities of students, teachers and families, for instance via a digital textbook (Svenska kunskapsförlaget, 2023) and school students visiting to an archaeologist suggested in a thematic teaching resource (Naturvetenskap och teknik för

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alla, 2018). Although, no insights into what specific form of collaborations (*narrow, narrow-broad* or *broad*) are wished for could be gained, it was clear that the collaborations are considered valuable for the Swedish primary school education. While Swedish school policy does not explicitly mentions on this topic, it prioritizes fostering connections with the surrounding world, especially concerning sustainable development. The Swedish National

Agency for Education (Skolverket) does not offer specific directives on how to integrate this into the curriculum.

Space: Soil (health) education in primary schools in Sweden is primarily conducted *indoors* with a few *outdoor* activities. Example of these outdoor activities include collecting samples (e.g. Naturvetenskap och teknik för alla, 2018) and performing experiments (e.g. Experimentarkivet, 2023; Lunds Kommun, 2023). The wish is to strengthen the *outdoor* components in soil (health) education.

Process: Soil (health) education at primary level in Sweden is predominantly facilitated via *instructive* process. However, there are often reflective elements involved taking a more *emancipatory* approach. For instance, programs such as LRF Sveriges bönder (2023) and Naturvetenskap och teknik för alla (2018) encourage students to reflect upon their own learning and perform independent tasks that includes posing their own questions, tasks such as collecting information to explain certain processes (e.g. decomposition), and conclude with open discussions and reflections. The policy representative mentioned in the interview that there has been significant debate in Sweden regarding whether the *instructive* or *emancipatory* process is the most effective way for children to learn. The wish is to facilitate education using the most age-appropriate process which appears to be primarily *instructive* for youngest age groups with gradually increasing *emancipatory* processes as the students advance.

> At younger ages, you work more with a sense of nature, the immediate area, and understanding it. Then, the questions become more and more complex as you progress through the year groups, adding more perspectives and connections - wicked problems that require more knowledge. It transitions from the close to the more complex and outward-looking.
> *-Policy representative (from interviews)*

Activities: In the primary education, soil (health) education is facilitated predominantly by a combination of *Knowing-based* activities (e.g. gaining knowledge from textbooks) and *doing-based* (e.g. performing laboratory experiments) activities. *Being -based* activities are uncommon. An example *of being-based* exercise, as learnt during the focus group included an activity where primary students and teachers wrote poem about the scent of soil. No clear wish for activities emerged.

Paradigm: A review of soil education resources for primary schools indicates an almost exclusive *mechanistic* paradigm, with specific focus on soil components, their properties and their functions together. *Ecological* paradigm is absent. No clear wish for paradigms emerged.

Gaps, challenges & opportunities

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Soil (health) education is not explicitly addressed in the national curriculum; however, soil-related topics, particularly soil composition and properties, are touched upon within various subjects such as biology or geography. This places soil (health) education on the sidelines, subject to the time and resources teachers can allocate to related activities. Despite the availability of extensive resources covering soil (health) topics, teachers struggle to incorporate them into their teaching due to limited teaching hours and the prioritization of curriculum topics. Additionally, primary education emphasizes the development of basic skills such as Swedish, reading, writing, and counting, leaving little room for soil (health) education. This raises questions about how to integrate it effectively. These challenges are further exacerbated by financial constraints, particularly for activities crucial for soil (health) education, such as laboratory experiments and field trips.
On a positive side, there is recognition to the importance of collegial learning and collaboration among teachers as well as encouragement for transdisciplinary education in Swedish school policy, that offers opportunities to adopt multidisciplinary approach to soil (health) education within context of the topics mentioned in the national curriculum, like food production, seasonal changes and life cycle of organisms.
To address these, curriculum may be revised to introduce soil (health) topics, and increase financial support for related activities (e.g. soil related experiments and field trips). Moreover, providing professional development opportunities for teachers can enhance their understanding of soil (health) and strategies for integration into the curriculum, addressing challenges related to time constraints and subject integration. Additionally, soil (health) topics are more likely to be addressed when connected to local problems or relevant issues, such as food production.

Secondary education

Vision: To integrate soil (health) and their connections with SDGs more deeply into the curriculum to align with the broader sustainability goals.
Needs: To revise the national curriculum to implement the core components of knowing, doing, and being in alignment to the Education for Sustainable Development roadmap.
Opportunities: There is an opportunity to tap into the existing collaboration of schools with external partners such as the Nature School and the Swedish Society for Nature Conservation to extend more outdoor, emancipatory learning experiences.

State and wishes of soil (health) education

Purpose: In secondary education in Sweden, there is a greater focus on global issues, with Education for Sustainable Development (UNESCO, 2020) deeply integrated into the Swedish education system. Various aspects of sustainable development are incorporated into most subjects, and while the SDGs are frequently mentioned, they are not always explicitly linked to soil (health). The purpose of soil (health) education in relation to the Mission Soil objectives and the SDGs varies depending on the subject. For instance, in chemistry, the focus is primarily on soil formation and composition. The biology addresses biodiversity in general (Skolverket 2022). In terms of specific EU mission goals,

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these subjects address *conserving soil organic carbon stocks* and *preventing erosion*, whereas other goals including some major issues in Sweden (e.g. *soil pollution and soil sealing*) are weakly embedded or missing. There are several SDGs that are although implicit yet present in soil (health) related education, most notably *zero hunger* (Gidhagen, M., & Åberg, S. 2012), *climate action, clean water and sanitation* and *no poverty*. Clear connections between soil (health) and other SDGs are missing.
The wish is to create greater focus on *improving soil structure to enhance soil biodiversity*, *sustainable consumption and production* and *climate action* (carbon sequestration.
In terms of human development, the purpose of soil (health) education at the secondary level appears to be primarily focused on *knowing*. From education policy perspective, this indicates a gap from the Education for Sustainable Development (ESD) which aims to go beyond knowledge acquisition and seeks to empower students with a sense of agency (*being*), promoting actionable steps toward sustainable development (*doing*). Agency, in this context, is the ability, grounded in critical thinking, to collaborate with others and take responsibility to effect positive change in the world. No insights into the wish for this aspect could be gained.

Collaboration: Soil (health) education in secondary schools in Sweden is predominantly *narrow* with occasional engagement of external partners. For instance, the textbooks are predominantly developed by teachers for teachers. An example of narrow-broad collaboration includes schools in Gothenburg collaborating with the botanical garden where students plant seeds in their schools under guidance of professionals. Also, Nature School, which specializes in outdoor pedagogy in partnership with schools (Naturskolan, n.d.) and the Swedish Society for Nature Conservation (Naturskyddsföreningen, n.d.), Sweden's largest environmental NGO, which offers free learning materials to schools through its program. No clear wish on the collaborations emerged, however, interviews revealed an interest in including relevant sectors, such as wastewater management utilities which produce sludge that can be applied to soil.

Space: A review of the course material indicates that they are offered either *indoors* or online, which a few exceptions of *outdoor* exercises. Examples of *outdoor* learning include programs offered by Nature School (Naturskolan, n.d.) which often take place in the schoolyard, parks, school gardens, or any other natural area near the school. Interviews provided further insights that, incorporating outdoor lessons becomes more feasible in upper secondary schools. This is because longer lesson times allow teachers to plan activities that require more time, making *outdoor* learning more practical. The wish is to combine both *indoor* and *outdoor* learning, allowing students to engage with the topic through multiple senses.

Process: A review of course materials shows that soil (health) education is mainly facilitated through *instructive* processes (e.g. textbooks aim to present numerous facts to the learners about the importance

> The national exams have a consequentialist approach to how the students succeed in applying their knowledge. One must reason, communicate, and argue for.
> *-Secondary teacher (from interviews)*

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of soil for food production, provisioning of nutrients and minerals, etc.). *Emancipatory* processes ae weakly embedded, and primarily exist as instructions provided to teachers within the textbooks. For instance, textbook suggesting teacher to let students reason based on provided pictures (e.g. cropland) and encourage them to think over and have a discussion on relatable questions, e.g. food production, biodiversity etc. No clear insights into the wishes for process were gained, however there is some apparent wish to integrate more *emancipatory* processes.

Activities: At secondary school level, *knowing-based* activities predominate soil (health) education, predominantly guided by the textbooks. *Doing-* and *being-based* activities are rare. An example is teacher instructions from Nature school (Lindeblad, 2022), where teachers are instructed to use a guided inquiry approach. This involves presenting students with some basic facts about Earth's surface and land use using a rope as a visual aid. Students then reflect on thought-provoking questions related to the importance of land and soil, followed by group activities that combine hands-on soil exploration and discussions. The wish is to facilitate education using the most age-appropriate processes that employ a combination of *knowing-* and *doing-based activities*.

Paradigm: Soil (health) education at secondary school level has a dominance of *mechanistic* paradigm. The curriculum focusses on educating on specific soil composition, properties and processes (e.g. soil types and composition) with lack of attention to soil and its role within broader ecological and earth system processes. No insights were gained regarding the wishes on this aspect.

Gaps, challenges & opportunities

> No teacher is interested in something that is not in the curriculum because then they are not doing their job. So you have to start there (at the curriculum). Find everything related to soil (health) and then have a plan for how to establish the concept of soil (health).
> *-Civil society representative (from interviews)*

Since there is no specific focus on soil (health) in the national curriculum, teachers are not encouraged prioritise it. This is further challenged by organisational and resource constraints that teacher face. Due to the specialized and segmented nature of subjects, and limited time available to incorporate extra topics and activities, leaves little room for incorporating soil (health) related topics or activities. This becomes more challenging for incorporating soil (health) education related *outdoor* activities due to lack of appropriate outdoor facilities at schools as well as financial constraints.

Despite these challenges, there are several opportunities to enhance educational experiences. Cross-disciplinary approaches can enrich soil (health) education, specially through *outdoor* and *emancipatory* approaches, through some planning and coordination among teachers. Providing teachers with ready-made exercises can streamline the implementation of practical learning activities. However, it is important to ensure that such materials are not biased if created by non-school actors. For instance, the forest industry may produce materials with a specific agenda, which can skew the educational content.

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Some suggestions include using school canteens as an opportunity for projects related to food waste management and soil nutrition, offering students a chance to engage in real-world applications of their studies. Swedish school policy emphasises on providing scientific evidence-based information, which seem to have created stronger focus on *mechanistic* paradigm around soil (health) teaching. While this does not conflict with the systems approach to soil (health), implementing it appears to be challanging.

Tertiary education

Vision: To increase the focus on soil structure especially in relation to biodiversity and crucial ecosystem services such as clean water to promote a comprehensive understanding of the importance of healthy soil and its broader impacts on sustainable development.
Needs: Incorporating a focus on the aspect of being in combination of knowing and doing.
Opportunities: Leveraging collaborative learning methods like Supplemental Instructions, which engage students in active participation and collective problem-solving, alongside peer learning, can significantly enhance learning experience and overall understanding of soil (health).

State and wishes of soil (health) education

Purpose: At the tertiary level soil (health) education, certain courses address the value of soil and its connections to the EU Mission Soil and SDGs very comprehensively, with relatively greater emphasis on *conserving carbon stocks, improving soil structure to enhance soil biodiversity, life on land and zero hunger.* For instance, course on Sustainable Cropping Systems (Swedish University of Agricultural Sciences, n.d.a) address *preventing erosion, climate action* and *clean water and sanitation*, and the course Soil Science, Hydrology and Meteorology (Swedish University of Agricultural Sciences, n.d.b) addresses *climate action*. The textbook Cultivation of Field and Garden crops (Fogelfors et.al., 2023) takes a global perspective and addresses most of the SDGs. Wish is to increase the focus on *improving soil structure to enhance soil biodiversity,* and *clean water and sanitation. Improving soil literacy in society* was considered important as it would open doors to incorporating awareness on other aspects and challenges around soil (health).
In terms of human development, the purpose of soil (health) education is acquiring knowledge (*knowing*) and practical experience (*doing*). In most of the courses, *knowing* is considered a prerequisite for the *doing* (e.g. in developing professional skills where soil knowledge is applied in practice). For example, Agricultural Engineering programme (Swedish University of Agricultural Sciences, n.d. c), offers industry oriented education and combines lectures with business-oriented projects and internships within organisations, authorities and companies that allows student to understand the complexities of the agricultural sector. The purpose of *being* is absent. *Being* is wished to be embedded, however, but it remains unclear from the study whether there is a specific wish to integrate *being* alongside *knowing* and *doing*, or to allow it to naturally emerge as a consequence of *knowing* and *doing*.

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Collaboration: Tertiary level soil (health) education was found to have predominantly a *narrow-broad focus.* For instance, in "Project-based Course in Horticulture Project" (Swedish University of Agricultural Sciences, n.d.), students plan and implement a project in collaboration with the university and a horticultural or agricultural industry. *Narrow* and *Broad* collaborations are absent. There is an apparent satisfaction from the current forms of collaborations, and engaging more collaborators is seen as useful.

Space: The predominant learning space for soil (health) education at tertiary level is *indoors*, primarily during the seminars supplemented with *outdoor* learning, for instance during field work. The wish is to have both *indoor* and *outdoor* components.

Process: At tertiary level soil (health) education, a combination of *instructive* or *emancipatory* processes are used with a greater focus on *emancipatory*. For instance, the syllabus of the course 'Experimental Horticulture' (Swedish University of Agricultural Sciences, n.d. f) specifically mentions training the students towards being able to create and test hypothesis and draw conclusions from their scientific analysis, peer to peer learning through projects and components of public dissemination of the experience gained during the course. The wish is to facilitate soil (health) education starting with *instructive* processes to provide students with essential knowledge and skills, followed by the integration of *emancipatory* processes to promote independent learning.

Activities: At the tertiary level of education in Sweden, soil (health) education adopts a combination of *knowing-based* and *doing-based* activities. *Being-based* activities were found to be missing in the review of course materials and during the interviews and focus groups. While no clear insights into the wishes could be gained, there seems to be an apparent satisfaction with the combination of *knowing-based* and *doing-based* activities.

Paradigm: *Mechanistic* paradigms dominates in tertiary level soil (health) education in Sweden, where focus is on developing deeper understanding of soil and its specific roles in different ecosystem processes. While the complex interactions across different soil components, and with broader environment and ecosystems are covered, there are instances where these concepts are presented within an even broader context. The wish is to build the *ecological* paradigm upon the *mechanistic* paradigm by gradually presenting the complexity soil (health) and how it relates to the broader ecosystem functioning.

Gaps, challenges & opportunities

Due to the diversity of courses and programs available at the tertiary level, identification of broad gaps proved to be challenging. Nevertheless, there is a notable absence of *being-based activities* in the curriculum on soil (health) related courses, indicating a gap in the approach to engaging students in experiential and reflective learning.

Opportunities exist to embrace collaborative learning methods, such as Supplemental Instructions, which engage students as active participants in the learning process and foster collective problem-solving. Leveraging peer learning can also enhance comprehension and retention, especially in cases where students may find it easier to receive information from

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peers rather than teachers. These opportunities present avenues for enriching the soil (health) education experience and promoting deeper understanding among students.

Vocational educational training (VET)

Vision: To train future farmers who are technically proficient and deeply connected to the environmental and cultural aspects of agriculture.
Needs: To incorporate soil (health) into the curriculum of all relevant courses e.g. plant science and agriculture.
Opportunities: The existing collaborations with external farms and businesses can be expanded and formalized to strengthen practical learning components.

State and wishes of soil (health) education

Purpose: The VET education related to soil (health) in Sweden is primarily offered in connection to agriculture. These courses address several of the Mission Soil objectives and SDGs, specifically *preventing erosion, stopping soil sealing and increase reuse of urban soils and improving soil structure to enhance soil* biodiversity (Weidow, B 2023; Vilhelmsson, Å. & Rehnfeldt, L 2023), and *zero hunger, Climate action, clean water and sanitation*. *Reducing desertification* is not an issue in Sweden and hence is not embedded in the soil (health) related education. No specific insights on the wishes for these aspects were gained.

> Doing, being, knowing are links in a chain – *VET teacher (from interviews)*

In terms of human development, soil (health) education at VET level is primarily offered by agriculture-themed vocational high schools which aim to train the farmers, there is a focus on *knowing* as well as practical skill development (*doing*). *Being* is weakly embedded. An example is a textbook that acknowledges the strong symbolic meaning of soil, citing phrases used during funerals such as "from ashes to ashes and dust to dust," as well as references found in poems and sayings about national identity (Weidow and Andersson, 2023). Wish is to combine all three *knowing, doing* and *being* in the purpose for soil (health) education.

Collaboration: Collaborations in soil (health) education in VET in Sweden is predominantly *narrow-broad*. For instance, an upper secondary program 'Naturbruksgymnasium', focusses on training future farmers as mandatory fifteen weeks traineeships program (Swedish: Arbetsplatsförlagt lärande) during which students practice their skills at farms in partnership with school (Berga gymnasium 2024). *Narrow* and *broad* collaborations are weakly embedded. No clear wish for collaborations emerged.

Space: Most soil (health) education related VET programs are designed to combine *indoors* and *outdoors*. Due to focus of VET programs on learning practical, there are frequently on-site (e.g. farm land within the school premises) or at the farms or collaborating agro-businesses. An example is the course 'Regenerative Agriculture and Holistic Management' (Bäckedals folkhögskola, n.d.) which combines online (*indoor*) lessons focusing on theoretical knowledge with practical sessions where the students perform practical

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exercises and field observations on farms and related businesses. Wish it to strengthen the *outdoor* component, however there is a concern over its practicality for larger groups.

Process: In soil (health) education related VET programs, both *instructive* and *emancipatory* processes are present. An example is 'Goodla' — a communication project by the Swedish University of Agricultural Sciences (Goodla 2024). This program provides extensive educational material including an educational video related to soil (health), and a mobile application, 'How is my soil doing?'. These are accompanied with clear instructions on how to make a self-assessment of the state of soil in their fields based on various parameters following which, the young farmer is probed to think about their farming practices and its affect the soil structure. No insights into the wishes on this aspect were gained.

Activities: The VET education in Sweden is primarily facilitated by a combination of *knowing-based* and *doing-based* activities. Students gain knowledge through textbooks with knowledge heck section following each chapter, and then apply their knowledge and skills through practical exercises (e.g. In farm operations or composting). Most VET courses have access to farms or gardens. *Being-based* activities are rare and there are no example of a course where *being-based* activities are present could be found. No insights into the wishes on this aspect were gained.

> Teaching must take place on a scientific basis - mechanistic way of thinking, but still see it in context.
> *-VET teacher (from interviews)*

Paradigm: Depending on the objectives of the VET programs, soil (health) education is approached either from *mechanistic* or *ecological* paradigms. For instance, the upper secondary program 'Naturbruksgymnasium' adopts a *mechanistic* paradigm, and focusses on different soil components and processes (Skolverket 2023). Nonetheless, it also recognizes the symbolic and cultural significance of soil. In contrast, a course on Regenerative Agriculture and Holistic Management (Vilhelmsson & Rehnfeldt, 2023) offered by Swedish Folk High School, which is an adult non-formal and voluntary educational institution with a vocational emphasis, aligns more closely with the *ecological* paradigm. Drawing from the interviews, the wish was to have predominance of *mechanistic* paradigms.

Gaps, challenges & opportunities

There is no explicit mention of soil (health) in course descriptions for the 'agriculture' program, which focus on developing plant knowledge, as outlined by the Swedish National Agency for Education. While it is possible that soil (health) concepts are implicitly integrated into the curriculum, this lack of specific focus indicates a potential gap in soil (health) education. Despite this, no significant gaps across current state and future wishes for different analytical dimensions (e.g. collaboration, paradigm, process) are evident, and the most critical Sustainable Development Goals (SDGs) related to soil are addressed. However, the specific combination of teaching materials and exercises used by individual teachers remains unclear, though a variety of resources are available. To achieve the wish to incorporate more *outdoor* learning, there is need to create opportunities of outdoor facilities

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and creating a strategic plan to address practical challenges considering climatic conditions of Sweden as well as access to outdoor facilities.

General public

Vision: to enhance soil (health) awareness in society by emphasizing the importance of healthy soils in holistic terms that include ecosystem functioning and long-term human sustenance.
Needs: To adopt more engaging and sensory-based approaches that suit the needs and interests of diverse audiences (age, educational background, occupation and general interest).
Opportunities: Existing innovating collaborations (e.g. Food experiment – studio 2000) and initiatives (e.g. Down to Earth—Self Sufficiency: Then and Now) present valuable examples that can inspire new initiatives aimed at cultivating a deeper appreciation for soil (health) and its significance across historical and modern contexts.

State and wishes of soil (health) education

Purpose: There are several categories of soil (health) related educational resources available for the general public. These include self-learning books on related areas such as gardening, which address basic aspects of soil (health) (e.g. composting), as well as popular science books that delve deeper into soil (health) topics (Wallander 2015) In addition, there are several educational resources including YouTube videos (e.g. Framtidens frukt, 2021, Jan 12) available on organic or regenerative farming that explicitly or implicitly address soil (health). Several educational programs target children and families. Most of these programs do not explicitly address soil (health) but focus on related aspects, such as composting and the role of earthworms. This broad spectrum of educational resources share the common goal of *improving soil literacy in society*. There is little focus on *conserving soil organic carbon stocks*, *stopping soil sealing and increase re-use of urban soils*, and *reducing desertification*, likely because these issues are not directly perceived as relevant to the everyday lives of Swedes. These resources also address the importance of soil (health) in food production and hence *zero hunger* (Wallander, 2015), and *life on land*, and, to a lesser extent, *clean water and sanitation*.Other SDGs including those that are directly connected to *climate action* (i.e. how soils assist in carbon sequestration) is weakly present. The wish is to strengthen the connections of most of the and Mission Soil objectives and SDGs in soil (health) education for general public.

In terms of human development, the purpose is *knowing* and *doing* with a weak focus on *being*. An example of *doing* and *being* focussed soil (health) educational program is the 'soil party' — a part of transdisciplinary art and research project 'Humus Economicus' (Humus Economicus, n.d.). In soil party, people from local allotment gardens, urban gardens, and gardens with social or pedagogical purpose made 'soil coins' from the soils of their garden to represent the value of soil, primarily for food production, climate engagement and social sustainability. These coins were integrated into a social sculpture

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at an art exhibition celebrating the mutual relationships between humans, plants, and soil microbes. The wish is to have a balance of all *knowing, doing* and *being*.

Collaboration: The soil (health) related education for the general public is predominantly offered through *narrow-broad* collaborations which includes non-traditional educators such as museums representatives, farmers and grassroot initiatives. For example, a 'Food experiment - Studio 2000' - a collaboration between a farm, a restaurant and a museum aims to explore the relationship between a restaurant and a farm. It demonstrates how creative collaboration between a grower and a chef can create interactive, personal, and delicious food experiences. The food was served in the museum's restaurant to showcase to the general public how we can eat within the natural limits set by our environment. Further broadening of collaborations are welcome.

Space: While, majority of the educational resources for general public are offered via textbooks or online, the predominant learning space is *outdoors* as most of the resources encourage the learners to practice outside in fields and gardens. In addition, there are programs such as ''Down to earth—self-sufficiency then and now exhibition" which incorporate *outdoor* learning activities (e.g. outdoor garden in this case which supplements indoor exhibition). The wish is to emphasise on the *outdoor* learning.

Process: Soil (health) awareness offers for general public are predominantly facilitated through *instructive* processes. Most of the resources available to the general public on soil (health) related topics provide instructions (e.g. on gardening, composting, field-work etc). *Emancipatory* processes are weakly embedded. An example of *emancipatory* learning is museum that encourages people to perform experiments in the garden and learn by themselves (Tumba Bruksmuseum, 2023-24). The wish is to have both—*instructive* and *emancipatory* processes, with an emphasis on strengthening the *emancipatory* aspect and adjusting the balance to be age-appropriate. For instance, using more *emancipatory* methods for children.

Activities: Given the diversity of the approaches used in soil (health) awareness offers for general public, it was difficult to identify what forms of activities predominate. The exhibition ''Down to Earth—Self-sufficiency: Then and Now'' (Tumba Bruksmuseum, 2023-24) is an example where *knowing-, doing- and being-based* activities are integrated. Here, an art installation at the former Paper Mill museum tells the story of the mill's residents and their year-round efforts to achieve self-sufficiency, encouraging visitors to reflect on modern self-sufficiency. In addition, the film "The Subterranean Ones" educates visitors about soil microbes and our reliance on them. The exhibition combines factual information, an outdoor educational garden, and storytelling to connect contemporary lives with those from 100 years ago, effectively blending knowing, doing, and being-based activities. The wish is to adopt activities that combine all three: *knowing-, doing-*, and *being-based* activities.

Paradigm: Soil (health) awareness offers for general public adopt both *mechanistic* and *ecological* paradigms. For example, a book on soil, by Wallander (2015), presents detailed description of different components and processes of soil in a *mechanistic* manner, and acknowledges the system's complexity, existing knowledge gaps, and presents

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philosophical reflections on soil. On the contrary, online course on regenerative agriculture (Svensk Kolinlagring, 2023), presents the soil (health) within the context of agriculture from an *ecological* paradigm acknowledging the complexity of the relationships of soil, plants, other living organisms and environment. The wish is to transition towards a more *ecological* paradigm to capture the interest of the general public.

Gaps, challenges & opportunities

Current soil (health) education for general public is generally offered in connection with gardening and composting, there is insufficient discussion about the potential of soil as a carbon sink for climate action. Similarly, urbanization's impact on sealing and depleting value of farmland also receives little attention in public discourse, often due to a lack of awareness. Engaging the general public effectively requires moving beyond traditional *knowing* approaches and incorporate the aspects of *doing* and *being* that encompass learning using multiple senses and emotions. However, this is hindered by physical constraints such as limited *outdoor* facilities, particularly challenging in Sweden's prevalent cold climate.

To address these challenges, there is a clear need to increase awareness about soil's broader ecological functions and to integrate more engaging educational methods. This includes highlighting soil's role as a carbon sink and advocating for the preservation of agricultural land amid urban expansion. By leveraging interactive learning experiences and historical narratives, such as those involving composting and soil formation processes, there is an opportunity to deepen public appreciation and understanding of soil (health) and its ecological significance. Additionally, there is also need to acknowledge the complexity that exists in the nature and highlight that soil (health) is connected to broader ecosystem and human systems.

> If you talk about soil as living or about soil (health), then it cannot be done in mechanistic terms. Not if you divide it into components like a clockwork that can be taken apart and put back together again, because it is not a fixed state.
> – *An artist (from interviews)*

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A.13. Spain

In Spain, soil (health) education is mostly absent from school curricula. For example, in Catalonia, soil is only briefly mentioned in the fourth year of compulsory secondary education (DECREE 175/2022). Soil (health) education, therefore, is left to the initiative of teachers that often customize sessions based on their own interests. There is the availability of good materials and tools for primary and secondary educational levels. These resources, if effectively disseminated and utilized, can enhance the quality of soil (health) education. Teachers and lecturers usually find it difficult to balance conveying key messages and not oversimplifying soil (health) related subjects. Since most instructors are experts in other areas, such Biology or Chemistry, they lack adequate knowledge about soil. On the other hand, formal education often focuses on basic soil (health) related knowledge, leaving less room for additional enriching content. In Spain, scientists have historically focused on classifying soil, often using complex jargon that makes it difficult for students and the public to understand. Real-world application in soil (health) education is also challenging because soil teaching is often extremely segmented, mostly in secondary and tertiary education. Reconnecting rural and urban areas is crucial because it underlines the importance of soil in food production and water infiltration. It is vital to reinforce the soil-food nexus across all the educational levels in the Spanish context. The geographical diversity of Spain, with its mix of urban and rural areas, offers a unique advantage for soil education. The school approach is highly influenced by its geographical, open up the opportunity to reconnect with the soil in the surrounding areas. For example, there are greater opportunities for pupils to engage with soil, food production and nature in schools located in rural areas. The real-world soil contexts can be therefore, brought in classroom. A collaboration between schools in rural areas and the ones in urban landscape should be explored. While there is a desire for a more ecological paradigm, the mechanistic one is still prevalent in soil (health) education. This worldview is reinforced by the fact that soil (health) education often focuses on teaching certain job skills and soil in its uses rather than in its connection with other service systems.

Primary education

Vision: To create focus on the soil in curriculum with an emphasis on connections of soil (health) with broader environmental and societal issues to enrich students' knowledge and foster a responsible and informed citizenship.
Needs: Soil (health) education should be systematically integrated into the curriculum, rather than being confined to sporadic projects.
Opportunities: School Garden projects can serve as lighthouse initiatives, demonstrating the practical applications of soil (health) education. Museums also offer an opportunity of partnership in soil education, offering exhibits, workshops, and resources that complement classroom learning.

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State and wishes of soil (health) education.

Purpose: In Spain, soil (health) education at the primary education level focuses mainly on *improving soil structure to enhance soil biodiversity* and often emphasizes the importance of soil (health) in *reducing soil pollution and enhancing restoration.* A number of projects that involve school gardens and address EU soil mission and sustainable development goals have increased. Only few resources in primary education address the need to *improve soil literacy in society* (Aragón, Lourdes et al., 2021; Department of Education, 2024d, 2024a; Escutia, 2009; Setmana Bio.cat, 2024; Solé et al., 2020). Other EU Soil Deal Mission goals are not systematically incorporated into primary education (DECREE 175/2022).

> We can put soil at the centre of so many debates today.
> *-A Primary school teacher (from interviews).*

Occasionally, a few activities address SDGs and soil (health) education is often isolated from social issues (Badía et al., 2017; University of Lleida, 2018). For instance, when soil is studied within school gardens, the focus is on biodiversity and life (on land) (Escutia, 2009; Jiménez-Aleixandre et al., 2015; Solé et al., 2020), with occasional connections with zero hunger and good health and well-being, (Department of Education, 2024a; Escutia, 2009; Solé et al., 2020).

In terms of human development, soil (health) educational activities that promotes the *doing,* for instance experimental activities (Badía et al., 2017; Department of Education, 2024a; Spanish Soil Science Society, 2013a; University of Lleida, 2018) and practical trainings (e.g., on composting). Generally, soil (health) education in primary schools does not prioritize knowledge of soil composition and processes (*Knowing*) or the (inter-) personal development of students (*Being*). However, certain school garden projects have some degree of focus on increasing students' personal involvement (*Being*) (Department of Education, 2024a; Escutia, 2009; Solé et al., 2020).

> You need to study and understand the soil in order to appreciate it. Soil is an essential system for life... I think soil is very much ignored. We walk on it, but we don't even notice it.
> *-A primary school teacher (from interviews)*

When shaping the future soil (health) education at the primary level, the wish is to strengthen *improving soil literacy in society,* specifically regarding *conserving soil organic carbon stocks* and to raise awareness and develop students' critical thinking about *reducing soil pollution and enhancing restoration*. It should also enable students to develop understanding of the crucial issues related to *climate action*.

Collaboration: In the Spanish primary education, collaboration on soil (health) education is n*arrow.* When developing educational material, the proposals either come from teachers (Early Childhood and Primary Science Group - ICE UAB, 2015) or soil researchers (Spanish Soil Science Society, 2013b, 2013a; University of Lleida, 2018). Exceptionally, some schools collaborate with universities, publishers, and other educational representatives to design textbooks and teaching materials. For example, a primary school teacher and an experimental didactics expert (from interviews) led a project where children investigated the environmental and health impacts of dog waste in a park, and then launched a campaign to inform local authorities and promote soil hygiene. The wish is to make

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collaboration *Narrow-broad* and at least include schoolteachers and university (soil) to facilitate introducing scientific rigor. Forms of collaboration could also be explored between schools and museums such as CosmoCaixa, which could support the organization of educational activities and experiments around soil (health).

Space: Soil (health) education combines both *outdoor* and *indoor* activities at the primary level and includes practical work with soil samples (Badía et al., 2017; Department of Education, 2024a; Solé et al., 2020; University of Lleida, 2018).
The wish is to integrate both *Indoor* and *Outdoor* learning spaces.

Process: Soil (health) education is facilitated mainly through *instructive* processes, focused on hands-on activities (Badía et al., 2017; Department of Education, 2024a; Spanish Soil Science Society, 2013a). However, there are instances, such as in school garden projects, where an *emancipatory* process also occurs. These activities are not just about acquiring knowledge but also about fostering engagement in soil care (Solé et al., 2020). The wish is to follow an integration of both *Instructive* and *Emancipatory* processes.

Activities: There is a clear predominance of *doing-based activities* when facilitating soil (health) education. In the primary education context, these activities aim to teach specific aspects of soil, composting techniques, and gardening (Catalan Waste Agency, 2023a; Badía et al., 2017; Early Childhood and Primary Science Group - ICE UAB, 2015; Solé et al., 2020). The wish is to have soil (health) education facilitated through various methods including all three types of activities- *knowing-, doing- and being-based activities*.

Paradigm: Soil (health) education, at primary education level has a dominance of *mechanistic paradigm*, focusing on specific soil processes depending on the learning goal (e.g., gardening, or composting (Badía et al., 2017; Department of Education, 2024; Escutia, 2009; Spanish Soil Science Society, 2013a)). Few educat ional materials and resources take a broader view, considering soil in a more systematic manner and aligning with the *ecological paradigm* (Jiménez-Aleixandre et al., 2015). The wish it to have both paradigms integrated in the facilitation process. Soil (health) education should initially adopt a *mechanistic paradigm*, focusing on understanding soil composition and processes. Following this, it should shift to an *Ecological paradigm*, integrating this knowledge to support opinion-forming and decision-making. For instance, during interviews, a primary school teacher and expert in Didactics of Experimental Science suggested a learning model for soil that they called 'systemic soil triangle'. This model considers spatial (macro-meso-

> (Soil) is a subject that gives you the chance to go outside, to collect samples, and analyse them or observe the environment.
> *-A primary school teacher (from interviews).*

> I think it's a personal matter. A teacher who truly understands the importance of soil will be proactive in seeking alliances. Conversely, a teacher who sees soil as secondary among the various topics they have to cover will choose other contexts to teach science models, such as different subjects or themes.

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micro) and temporal scales to facilitate understanding of soil structure and composition, and their dynamics resulting from environmental interactions.

Gaps, challenges & opportunities

The primary challenge in soil (health) education at primary education level is to structurally integrate soil (health) into the curriculum, ensuring it does not rely solely on the interest of individual teachers. Teacher training also needs to emphasize soil (health). In addition, teachers must be motivated and equipped to incorporate soil studies into their lessons. Primary education training often focuses more on methodology than content and enhancing basic teacher training is crucial to motivate and encourage students to look for resources and prepare related activities. Alongside, there is a clear need for incorporating ecosystems perspective to soil (health) and facilitate collaborations between different disciplines and sectors. There are some ready-to-use resources shared by interviewees from the primary education level, such as a 'soil box' that contains materials and experiment proposals, which teachers can use in their teaching.

> Soil (health) education must address these three levels: describing, explaining, and defending proposals for action. Students can't advocate for something without understanding it, so they must describe, explain, and argue based on their knowledge. Only by viewing soil as a system will students develop sound criteria for scientific and socio-economic decisions.
> *-A primary school teacher (from the interviews)*

Secondary Education

Vision: To make soil (health) a main focus in the secondary education curriculum.
Needs: To broader the collaboration to support the integration of practical, real-world knowledge into the curriculum.
Opportunities: Student involvement in citizen science initiatives can reinforce the needed emancipatory process in soil (health) education.

State and wishes of soil (health) education.

Purpose: In Spain, soil (health) education at the secondary education level focuses mainly *on improving soil structure to enhance soil biodiversity* (Universitat Autònoma de Barcelona, 2023k; Virto, I et al., 2019; Zuazagoitia & Villarroel, 2016), *to improve soil literacy in society*, and to a degree on *reducing soil pollution and enhancing restoration*. Generally, the connections of soil (health) with the SDGs are generally missing, (Department of Education, 2024a). In cases where soil education is included in projects with a broader scope, discussions on *life on land* (Zuazagoitia & Domingo, 2016) is present. The wish is to strengthen the *improving soil literacy in society*, *quality education,* and *affordable and clean energy*.

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In terms of human development, usually soil (health) education activities shaped by external experts or trained teachers promotes the *doing (Department of Education, 2024a; Oriol Guinart, 2024; Peña et al., 2016; Spanish Soil Science Society, 2013a; Virto et al., 2019; Zuazagoitia & Domingo, 2016)*, while those within the formal curricula promote the *knowing* (Department of Education, 2024c). Soil (health) education is wished to involve all the three aspects of human development: *Knowing, Doing* and *Being.*

> Three ideas should be made clear to students in relation to soil are: first, existence (soil is something with certain characteristics); second, diversity (not all soils are equal); and third, dynamism (like any other element of the ecosystem, soil changes).
> *- Secondary school teacher (from interviews).*

Collaboration: In soil (health) education Spanish secondary education level is predominantly *narrow* collaboration, primarily involving teachers and students, and sometimes experts in the didactics of the subject (Oriol Guinart, 2024; Virto et al., 2019) and soil researchers (Spanish Soil Science Society, 2013b, 2013a). There is some *narrow-broad* collaboration, for instance between rural schools and farmers. The wish is to establish *broad* collaborations that include schools and other agents such as research and pedagogical resource centers.

Space: Most of soil (health) education take place *indoors (*López Pérez & Boronat Gil, 2016; Oriol Guinart, 2024; Virto et al., 2019). *Outdoor* activities are less common and often take place in specific workshop settings (Department of Education, 2024b). The wish is to combine *outdoor* (such as conducting observation trips) with *indoor* (such as, analysis of soil samples in the laboratory and classroom discussions educational activities).

Process: Soil (health) education is mainly provided through *instructive processes*, which are necessary as a first step to understand biological, physical, and chemical processes. The wish is to strengthen the *emancipatory process* through students' participation in citizen science projects.

Activities: Educational design proposals from the Department of Education predominantly present *know-based activities* (Department of Education, 2024c). On the contrary, proposals from teachers, workshops, and didactic experts emphasize *doing-based activities* (AEPECT, 2023; Department of Education, 2024b; López Pérez & Boronat Gil, 2016; Spanish Soil Science Society, 2013; Virto et al., 2019; Zuazagoitia & Villarroel, 2016). It is wished that soil (health) education includes *knowing, doing, and being-based activities*.

> Contents about soils in secondary school are somewhat scarce and very much depend on which book or materials the teacher chooses. It is not something that is always on curricula. Many students go through secondary education without this training…there is no need for a specific subject around soil. Soil is present in many topics and could be mentioned at various times or addressed transversally in several subjects.
> *-A university lecturer (from the interviews).*

Paradigm: Many educational practices are shaped by the *ecological paradigm*, often emphasizing the need for healthy soil in connection with biodiversity and forest conservation (López Pérez & Boronat Gil, 2016; Peña et al., 2016; Virto et al., 2019; Zuazagoitia & Villarroel, 2016). The wish is to make *mechanistic* and *ecological paradigms*

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complementary. Actors involved in secondary education level suggest initially approaching soil from a mechanistic perspective, then from an ecological one.

Gap, challenges & opportunities

Various scientific and education professional associations have highlighted the lack of incorporation of geology and soil within the curriculum (Cortés Gracia & Martínez Peña, 2017, 2020; Spanish Soil Science Society, 2017). Since it is difficult to deviate from this compulsory curriculum, there is limited focus on the soil (health) related topics. Additionally, teachers lack training on the necessary skills for

building partnerships to promote soil (health) education. Collaboration should be fostered between schools and practitioners involved in soil management and conservation. Definitely, schools with a nearby forest are more likely to carry out outdoor educational activities around soil (health).

General public

Vision: To embed tertiary-level soil (health) education in designing policies concerning soil conservation, and land use.
Needs: To integrate soil (health) education across various disciplines to address the complexity of soil and equip students for to addressing real-world soil (health)-related challenges, especially considering the lack of a specific degree in Soil Sciences in Spain
Opportunities: Adopting an ecological paradigm might help close the gap can between theoretical knowledge and practical understanding.

State and wishes of soil (health) education.

Purpose: the purpose of soil (health) education, at tertiary level, varies depending on the field of study. For example, most education degrees focus on *(improving) soil literacy in society* and include basic information on soil and its didactics (e.g., Universitat Autònoma de Barcelona, 2023a, 2023j, 2023c, 2023d, 2023h;).

> Soil is a portrait of our society.
> -A u*niversity student (from interviews).*

On the other hand, in agriculture degrees soil (health) is studied mainly in relation to its function in crop management. Consequently, in agriculture related degrees, purposes include *reducing desertification, conserving soil organic carbon stocks, reducing soil pollution and enhance restoration, improving soil structure to enhance soil biodiversity* (University of Barcelona, 2023d, 2023e; University of Barcelona et al., 2024). Forestry management degrees focus on soil's role in woodland systems and therefore in *preventing erosion (*University of Lisbon et al., 2024; University of León et al, 2024). Environmental science or biology degrees focus on soil structure and properties (*improving soil structure to enhance soil biodiversity)* without addressing directly soil (health) (e.g., Universitat Autònoma de Barcelona, 2023b, 2023e, 2023f, 2023g;). Finally, soil (health) education in agroecological production degrees seems to find a close connection with various SDGs like *clean water and sanitation, industry, innovation and infrastructure, sustainable cities and communities, responsible*

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consumption and production, climate action, life on land (University of Lisbon et al., 2024; University of Barcelona, 2023d, 2023e). However, broader SDGs connected with socioeconomic aspects are not reflected in curricula. These include SDGs like *no poverty, good health and well-being, gender equality, peace, justice, and strong institutions* (University of Lisbon et al., 2024; University of Barcelona, 2023d, 2023e). The wish is to design soil (health) education by incorporating the historical, philosophical and artistic contexts to soil in addition to the scientific context. In addition, it is also wished to reinforce the cultural nature of soil by *improving soil literacy in society*, consider soil diversity in generating affordable *and clean energy* and for *stopping soil sealing and increasing re-use of urban soil*s, and stress the connection between soil (health) education and *sustainable cities and communities*. Additionally, the wish it to also emphasise on the importance of soil (health) for *good health and well-being and clean water and sanitation*).

In terms of human development, most environmental science and agriculture and forestry management curricula focus on the purpose of *knowing*, while education degrees focus more on the development of *doing* (e.g., Universitat Autònoma de Barcelona, 2023j; University of Barcelona, 2023b, 2023c). The purpose of fostering a deeper connection with soil (*being)* is nearly missing. The wish is to emphasis on *doing* and *knowing* for more sustainable land management.

Collaboration: In bachelor's degree programmes, collaboration is *narrow.* Each university department usually prepare its own subject programme with minimal collaboration form other disciplines, often due to time constrains (Universitat Autònoma de Barcelona, 2024; University of Barcelona, 2024;). In master's degree, collaboration is *broad*: Knowledge from different geographical areas is integrated with universities from different regions and areas of expertise working together (e.g., University of Barcelona, 2023d, 2023e.). Occasionally, there are opportunities collaboration between university, VET cycles, and private companies with experience in soil regeneration. These companies, often sensitive to the soil (health) issues, offer fieldtrips where students can visit different types of landscape. There is a clear wish for broader collaboration (*narrow-broad* or *broad*) in soil (health) education, involving various societal stakeholders. This collaboration should include public administration to emphasize the necessity of incorporating soil (health) into formal curricula. Faculties should collaborate to foster integration of soil subjects across various university degrees.

Space: Most environmental science curricula and degrees related to agriculture and forestry management, lack specific practical work that focus on soil (health). Consequently, education is mostly *indoors* (e.g., Universitat Autònoma de Barcelona, 2023b, 2023e; University of Barcelona, 2023a). However, interviews reveal that there are several examples of *outdoor* education, such as in the university degrees focusing in Edaphology (e.g., Agronomic and Forestry Engineering, Environmental Sciences and Pharmacy). In such courses, teachers take students to different *outdoor* locations to describe soil profiles and show the connection between soil and landscapes. Sometimes, samples collected (*outdoor)* are analysed in the laboratories (*indoor)* for studying their physical and

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chemical properties. In classrooms (*indoor)*, methods like naming soil characteristics, showing photos of various soil types, and making posters on specific soils are used to teach soil diversity. It is wished to make soil (health) education *outdoor* as far as possible, for example through field trips to agricultural companies, farms, etc.

Process: Degree programmes, usually, follow an *instructive* approach: learning process is shaped by predefined instructions and curricula, which leave little space for opportunities of knowledge construction (e.g., Universitat Autònoma de Barcelona, 2023b, 2023e; University of Barcelona, 2023a). Unlike traditional methods that prioritize direct instruction, knowledge construction empowers students to actively shape their learning. However, interuniversity master's programs - graduate-level course of study that are offered jointly by two or more universities- seem to adopt a more *emancipatory process*, as indicated by their 'tudy guides' general descriptions (e.g., MSc European Forestry, 2023; University of Lleida, 2023b). There is a clear wish for soil (health) education to incorporate more emancipatory processes.

Activities: Soil (health) education is mainly facilitated by *knowing-based activities*. In environmental sciences and agriculture-related, and forestry management curricula, *doing-based activities* focusing on soil are minimal and limited to internships or fieldtrips (e.g., Universitat Autònoma de Barcelona, 2023e, University of Barcelona, 2023a; University of Lleida, 2023c). There is a growing interest in *being-based activities*, as observed in educational practices like forums, exhibitions, and soil judging contests (e.g., Soil Judging Contests by the UdL (Pallarsjussa.net, 2019), the Spanish Soil Science Society (SECS) and the Cartographic and Geological Institute of Catalonia (ICGC) (Sanchez Herranz, 2015, Balasch et al, 2019)); the scientific escape room, Perfilina, at the University of Zaragoza designed by CSIC researcher Carmen Castañeda.). The wish is to diversify the educational approaches to soil departing from pure academia and integrating historical, cultural, philosophical, artistic aspects. There is a clear need to broaden the adoption of *being-based activities* that can enhance students 'engagement in soil subjects.

Paradigm: Soil (health) education incorporate both *ecological* and *mechanistic paradigm*, depending on the degree programme. While, many bachelor and master's programmes align with an *ecological paradigm*, underlying soil as to be studied in a broader ecological system functioning and the provisioning of goods and services under global change. Some examples include Forest Management (Medfor, 2023), Agro-Food Transition (University of Girona, 2023a, 2023b, 2023c), and Terrestrial and Aquatic Ecosystems (University of Lleida, 2023a). Historically, soil-related subjects have been taught from a *mechanistic paradigm*, being especially focused on soil chemistry and disconnected from concrete applications. Currently, this abstract way of teaching about soil is changing and applying contexts of the *Ecological* paradigm. The wish is to embrace the *ecological paradigm* in soil (health) education as students also express during interviews desire to incorporating elements of poetry, philosophy, and culture to enrich understanding beyond mere productivity aspects of soil (health).

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Gaps, challenges and opportunities

> Soil is a continuum of observation on all scales, from microscopic to landscape.
> *-University lecturer (from interviews)*

One main challenges of soil (health) education, at the tertiary level, is the lack of educational activities fostering a deeper connection with soil. Studying soil is challenging because it is complex and not easily seen. To understand it fully, knowledge from Physics, Chemistry, and Biology needs to be combined. Furthermore, academic and departmental priorities considerably shape curricula design, influencing the inclusion of soil-related subjects in programmes.

The shift towards holistic approaches, such as those in biodynamic or regenerative agriculture, poses challenges within the ecological paradigm that end up being seen as less focused on conceptual and factual knowledge. Lastly, government should support the expanding and maintaining of soil (health) education, ensuring its integration into tertiary curricula.

Vocational educational training (VET)

Vision: To design a comprehensive soil (health) education program that underlines the role of soil in agriculture and human health.
Needs: To integrate farm-field trips into the VET curriculum to provide students experiences of different agricultural practices, presenting exemplary models of soil management.
Opportunities: VET education holds opportunity to bridge the knowledge gap about food production between urban and rural populations, reinforce the Food-Soil Nexus, and educate urban populations about the link between soil (health) and food quality

State and wishes of soil (health) education.

Purpose: At VET level, there is a significant connection of soil (health) education with agriculture, particularly in teaching how to manage organic family farms or food processing management. The purpose of soil (health) education at VET level primarily addresses EU soil mission goals that include *reducing desertification, conserving soil organic carbon stocks, preventing erosion, reducing soil pollution and enhance restoration and improving soil structure to enhance soil biodiversity* as well as SDGs such as *climate action* and *life on land*. For example, the Agricultural School of Manresa emphasizes the importance of healthy soils to meet the needs of different crops. This practical training focuses on specific agricultural practices and broader EU mission goals like *reducing the EU's global footprint on soils* and *improving soil literacy in society* are addressed implicitly as observed in the laws promoted by Catalan Government in 2013 , which establishes the curriculum for the Intermediate VET Cycle on Olive Oils and Wines (DECREE 177/2013) and in 2015 which establishes the curriculum of the Higher VET Cycle in Landscaping and Rural Environment (DECREE 215/2015). The wish is to equip people working in the field with tools for *improving soil structure to enhance soil biodiversity, conserving soil organic carbon stocks* and raising awareness for *responsible consumption and production*.

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In terms of human development, VET Cycles, for example, which are post-compulsory vocational education programs offering specialized training closely linked to various professional sectors are designed to be practical and environmentally applied, preparing students for fieldwork. Hence the main focus is on "a practical purpose" (*doing*) (Agricultural School of Amposta, 2024; Agricultural School of Manresa, 2024b). Few agricultural schools also focus on the need for ecological agriculture with the purpose of nurturing sustainability awareness (*being*). There is a need to improve soil (health) education in order for society to be encouraged to practice responsible consumption and production (*being*).

Collaboration: Collaboration in soil (health) education is primarily *narrow-broad*. Often agricultural schools cover different subjects, including technical and applied sciences, academic studies, and labor management. All the agricultural schools have farms for practical work (Agricultural School of Manresa, 2024a) where students apply the knowledge acquired during the VET Cycle. In some cases, VET staff collaborates with other institutions, such as universities (University of Barcelona, 2023d. Furthermore, there is a strong collaboration between agricultural schools and agricultural producers, some of whom are alumni. Associations of agricultural producers request specific continuing education courses from these schools. Finally, the Government of Catalonia's Ministry of Climate Action, Food and Rural Agenda (DACC) encourages a broader collaboration supporting the network of agricultural schools. Bottom-up collaboration between agricultural schools and agricultural producers who can show students case studies that are already operative should be promoted. The wish is to expand collaboration between farmers and researchers from universities and research centers (Narrow-Broad).

> I imagine a student saying "Wow, I tried some awesome cherries from an organic farm, big like the others, but what a different taste they had. And that day they taught me how to work the soil.
> *-A VET representative (from interviews).*

> t is through our food that the story of soil can be told.
> *-A VET representative (from interviews).*

Space: Classes and training courses on soil (health) are mainly practical and are conducted *outdoors* on agricultural farms owned by the school (ECA of Manresa, 2024), which allows students to work in real conditions. Field observation is often combined with laboratory work (*indoor* and outdoor). Despite the integration of field trips to the formal curriculum, there is a wish for more *outdoor* education, especially to farms and productions fields, where student can understand different types of agriculture (conventional, organic, etc.) and learn examples of good land use.

Process: The curricula of the VET programs (DECREE 53/2013, DECREE 177/2013) are characterized by an *instructive process*. The VET courses are based on specific guidelines and taught techniques. Emancipatory processes are less common. For instance, training course on organic agriculture production (Alfarràs Agricultural School) presents an example, where there is a balance of *instructive* and *emancipatory* approaches. The wish it to further encourage *emancipatory processes*.

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Activities: VET programs and permanent training courses—which are short-term offerings by Agricultural Schools to update employed workers' knowledge in the sector— focus on practical, real-world environmental contexts learning to prepare students for employment, with a predominance of *doing-based activities* (Agricultural School of Manresa, 2024a; Government of Catalonia, 2024, Agricultural School of Amposta, 2024; Agricultural School of Manresa, 2020). The wish is to incorporate the three types of activities, *knowing-based, doing-based, and being-based*. Such holistic approach is needed to shape learners' views and behaviors.

Paradigm: Bases on the desk research, soil (health) related courses in VET programs are mostly shaped by *ecological paradigm*. Soil is studied in connection to its roles in contexts such as crop management, (DECREE 228/2013, DECREE 233/2013), or forest and landscape management (DECREE 215/2015) However, during interviews, it emerged that the predominant paradigm in soil (health) education tends to be *mechanistic*, focusing predominantly on specific processes such as production processes, chemical effects of fertilizers. The wish it to have the *ecological paradigm* to shape the design of soil (health) education.

Gap, challenges & opportunities

VET students, and future agricultural professionals, need to develop a holistic approach to soil (health). Soil (health) education, therefore, must acknowledge and address the complexity and the interdependent relationship between soil (health) and ecosystems. This understanding is fundamental for promoting practices that promote soil (health). By enhancing soil (health) education at a VET educational level, we can increase awareness of how healthy soil has an impact on food quality and overall health.

> We don't have to teach about soil alone [..] working on soil alone without linking it to food is very sterile.
> *-A VET representative (from interviews).*

General public

Vision: To foster a deeper understanding of soil's essential role in ecosystems and human well-being.
Needs: There is a clear urgency for a soil directive to address pressing challenges such contaminated soils, complex land ownership issues, and regulation of soil (health) education.
Opportunities: Existing collaboration across sectors and educational levels open up a chance to integrate soil (health) education into formal and non-formal curricula.

State and wishes of soil (health) education.

Purpose: Soil (health) education, at the general public level, varies in its purpose depending on who is involved in its design. Public bodies (administrative entities, e.g.) and researchers often focus on the *conservation of soil organic carbon stocks, reducing soil pollution and enhancing restoration, and improving soil structure to enhance soil biodiversity* (e.g., Catalan Waste Agency, 2013, 2020 2021a.). General public educational activities often address issues related to soil regeneration or adaptation *to* climate change (*climate*

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action) (CREAF, 2020-2024; CTFC, 2017, 2021; Institute of Nutrition and Food Safety Research, 2023; Retana & Gracia, 2021; LIFE AGRICLOSE, 2022, 2023; University of Valencia, 2023). These also cover *reducing desertification and improving soil literacy*. Publications and educational material elaborated by public administrations, research centers, and environmental associations focus mainly on SDGs like *good health and well-being, clean water and sanitation, sustainable cities and communities, responsible consumption and production, climate action*, and *life on land* (e.g., Catalan Waste Agency, 2013, 2020, 2021a, 2023c, 2023a, 2024). Unlike education at other levels, most of the materials that are disseminated among the general public, on soil (health), are intended to engage (*being)* and raise awareness (e.g., Catalan Waste Agency, 2023b, 2023a, 2023d, 2024; Poch, 2023; Poch et al., 2022). Meanwhile, interviews reveal that, often, non-governmental organizations, such as the Era Association (Era Associaction, 2022), and civilian groups, such as the Catalan Institute of Agricultural Sciences (ICEA)(Balasch et al, 2019), work to ensure that soil (health) education helps society acquire knowledge about the soil (*Knowing)*, learn how to treat it (*Doing*), and foster transformative learning (*Being*). The wish is to strengthen the focus on *improving soil literacy in society,* in addition to *reducing soil pollution* and *enhancing* its *restoration.* In the context of SDGs, the wish is to provide *quality education* in the broadest sense, with clearly demonstrating the value of soil (health) for *zero hunger, decent work, and economic growth* (e.g., by appreciating the farmers and their socioeconomic status) and *climate action*. Highlighting soil's cultural significance is as fundamental as knowing about the human body, cities, rivers, or classical literature. Understanding soil and its essential functions, including its role in nutrition, is vital for survival, as emphasized by the interviewees. In terms of human development, the wish is to emphasize *being* when defining the purpose of soil (health) education at the general public level. It is essential to enhance education in soil (health) to inspire society towards responsible consumption and production.

Collaboration: Although many different societal agents are involved in soil (health) dissemination on soil (health), collaboration between them remains *narrow***.** Many of the educational materials, at the generic public level, are produced by a single agent (Department of Edaphology and Agricultural Chemistry, 2014; Dorronsoro, 2023; Retana & Gracia, 2021; University of Granada, 2023; University of Sevilla, 2015; University of Valencia, 2023). However, there are cases of *narrow-broad* collaborations between research projects although, limited to the dissemination process (L'Era Association, 2022; Regensol, 2023). Interview revealed some other cases of *narrow-broad* collaboration for instance between association promoting agroecology and food sovereignty, and agriculture schools. The wish is to make collaboration *narrow-broad* and involve public administration, educational and social agents, and the production sector.

> There is a lack of transfer of knowledge and technology and engagement with reality -An *NGO representative (from interviews).*

Space: Most non-virtual educational proposal take place *outdoors*, either in public spaces be (Poch et al., 2022) or on the field (CREAF, 2020; L'Era Association, 2022; Pallarsjussa.net, 2019; Royo, 2023). Interviews reveal that educational activities addressing the general

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public are conducted both *indoor* (conferences, debates, talks, training) and *outdoors* (field trips, visits to farms and experimental farms). For example, The Office for Fertilization and Treatment of Livestock Manure of the Ministry of Climate Action, Food and Rural Agenda (DACC) focuses on the farming community, promoting visits to experimental farms to show the effects of specific fertilization practices. The office also supports farmers with several training courses. The wish it to have both *indoors* and *outdoors* educational activities to engage with the general public.

Process: Soil (health) education, at the general public level, is facilitated mainly through an *emancipatory process.* This process allows not only to inform people about soil but also to connect people with its vital role (Catalan Waste Agency, 2023b, 2023a, 2023d, 2024; Poch, 2023; Poch et al., 2022; Vida Verda, 2023). Sometimes, non-governmental organizations attempt to combine *emancipatory* and *instructive processes* when designing engaging educational activities for the public. The wish is to shape soil (health) education that combines both *instructive* and *emancipatory processes* to boost knowledge and create awareness among society. Soil issues should be linked to people's experiences and everyday life to change attitudes and behaviors. Encouraging the general public to join discussions on different ways to use and manage land can increase their involvement and interest in issues related to soil and land. For example, they could participate in debates about the 'peasantry model,' a topic currently receiving a lot of attention in Catalonia.

Activities: Most educational materials and activities on soil (health) are designed through *being-based activities* with the aim to engage and raise awareness of the need for healthier soil (Catalan Waste Agency, 2023b, 2023a, 2023d, 2024; Poch, 2023; Poch et al., 2022; Vida Verda, 2023). They are sometimes supported by *doing-based* (Pallarsjussa.net, 2019; Royo, 2023) or *knowing-based activities* (Catalan Waste Agency, 2023d; Armengol Segú, 2014; Ascaso-Sastrón et al., 2015; Balasch et al., 2019; Cartographic and Geological Institute of Catalonia, 2024; Retana & Gracia, 2021; LIFE AGRICLOSE, 2023; Poch et al., 2022; Sánchez Herranz, 2015). Examples of *being-based* activities include publications and newsletters (such as Agrocultura and Agricultura del Sòl Viu) to disseminate ideas and information on soil (health) to a wide audience; specialized training and courses (for examples, the one provided by Agricultural School of Manresa) for farmers to raise awareness on specific soil (health) issues. In fact, these activities emphasize the integral role of human beings within the ecosystem, advocating for a respectful balance and careful management of soil equilibrium. The wish is to focus efforts and resources to include further *being-based activities* in soil (health) education.

Paradigm: Most of the educational materials, at the general public level, are shaped by the *ecological paradigm* (Catalan Waste Agency, 2023d; CREAF, 2020, 2024; L'Era Association, 2022; Poch, 2023; Regensol, 2023; Vida Verda, 2023). Although the mechanistic paradigm is weakly embedded, it is still considered essential for understanding soil subjects. The wish it to shape soil (health) education according to the *ecological paradigm.*

Gaps challenges and opportunities

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Soil (health) education faces different challenges, from the difficulty of defining "soil (health)" to the absence of a clear soil directive, unlike those for air and water. Consequently, the main challenge of soil (health) education consists in introducing the related knowledge to the society. In order to have the necessary social impact, soil (health) education needs a broader collaboration across the education spectrum, involving other sectors, such agriculture, forestry, and public administration. Specific initiatives, mostly from non-governmental organizations, can function as exemplary cases but they require greater financial support and organizational efforts to reach their full potential. In the agricultural sector, and therefore among farmers, there is a need for a continuous training to promote regenerative practice and therefore soil (health)-related issues. However, this shouldn't address only the stakeholders involved in the agro-production, but also the urban population that needs to reconnect with soil. Soil needs to be prioritized, not only in formal education, but also in societal debates about sustainable land management and consumption practices.

> There is a need for a soil directive. At the moment this at the public inquiry stage. We identify three basic problems. The first is that there are contaminated soils and many chrematistic interests […] The second is that soil has an owner […]. And the third is that soils are diverse […]. All this makes it very difficult to produce a directive.
> -A *civil society representative (from interviews).*

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A.14. Turkey

In Turkey, the focus and depth of soil (health) education varies across different levels and programs. In primary education, there is a greater emphasis on the structural aspects of soil. In secondary education, soil (health) education is integrated into biology and geography courses, and its links to broader Sustainable Development Goals (SDGs) are incorporated. At the tertiary level, soil (health) education is more deeply integrated, and the exploration of its connections to SDGs expands further. The revised VET curriculum has bridged the gap between *instructional* and *emancipatory* processes, and *outdoor* and *indoor* education, yet the soil (health) education remains within the limited context of agriculture. The general public seems to have relatively accessible courses on gardening and horticulture yet soil (health) aspects are not explicitly addressed in such courses.

One significant wish to enhance soil (health) education is to achieve a balanced approach of knowledge acquisition (*knowing*), alongside practical experiences (*doing*) and developing an appreciation of soil's intrinsic value (*being*). There is also a desire to broaden collaborations and involve stakeholders such as farmers, civil society, businesses, and agricultural vocational schools.

Emphasizing *outdoor* learning spaces and activities is another key aspiration, with a vision to facilitate a connection with the natural environment. Finally, there is a wish to acknowledge the interconnectedness of soil with broader ecosystem processes and human society, by approaching soil (health) from a systems perspective.

> Soil health is an important problem that affects all of us and will affect us even more. We live in an age where we cannot solve problems alone and must establish more effective collaborations. At the same time, we are in an age where everyone is very busy and the workload is high.
> *-A primary school teacher (from focus group).*

Methodological considerations: In Turkey, secondary education (the terms of high school or Lise are used instead) includes nine types of schools. This research analyzed the curricula of the following four secondary school types: Anatolian High School, Social Sciences High School, Science High School, and Imam Hatip High School (religious education).

Primary education

Vision: To Transition towards outdoor, emancipatory, and holistic approaches to soil (health) education.

Needs: To embed broader concepts of soil (health) in the national curriculum and create opportunities for more outdoor, experiential forms of learning via expanding resources towards recruitment and training of teachers.

Opportunities: The national education program's endorsement of emancipatory approaches offers an opportunity to demand curriculum revision that prioritizes teacher empowerment through enhanced opportunities and resources.

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State and wishes of soil (health) education

Purpose: The National Education Curriculum for primary schools in Turkey places emphasis on the structural aspects of soil (e.g. soil formation) and lacks focus on soil (health). The connection of soil (health) with the SDG-*life on land* along with two EU mission objectives—*preventing erosion* and *reducing desertification* are embedded, particularly in the courses of Life Science, Science, Social Sciences, Environment, and Climate Change. While the curriculum also touches on certain aspects of *improving soil structure to enhance soil biodiversity, conserving soil organic carbon stocks reducing soil pollution, and enhancing restoration,* it lacks addressing other EU Mission Soil objectives. Soil activities are included in TEMA Foundation (The Turkish Foundation for Combating Soil Erosion, for Reforestation and the Protection of Natural Habitats) education programs such as Yavru TEMA and Ortaokul TEMA which are provided freely for primary schools. Both programs address additional soil (heath) topics, specifically *improving soil structure to enhance soil biodiversity and improve soil literacy in society* (TEMA, 2015a and TEMA, 2016). The linkages between soil (health) and SDGs such as responsible consumption and production and climate action are weakly presented in the curriculum and broader socioeconomic SDGs are missing. The wish is to create emphasis on improving soil literacy in society.

In terms of human development, the purpose of soil (health) education is focused primarily on *Knowing.* For instance, in the science lesson curriculum of the national education (MEB, 2018a), students gain knowledge on classifying living and non-living things using examples from their environment. There is a weaker emphasis on *doing*, and *being* is almost missing. Nevertheless, some schools seem to recognize the value of an integrated purpose of *knowing, doing,* and *being* as exemplified in the Ankara University School of Soil Science (Ankara University, n.d.) targeted at primary school students. In this one-day course, students gain knowledge (*knowing*) about the importance of soil through an engaging curriculum. They participate in hands-on experiments to understand soil's properties (*doing*) and become aware about the value of soil and the environment (*being*). Through this experience, the program also aims to fosters a lifelong commitment to soil conservation and scientific inquiry, with a strong emphasis on cultivating their sense of responsibility (*being*).

Collaboration: Soil (health) education in primary schools in Turkey is predominantly narrow-broad. In the first grades of primary school education, schools mostly work in close collaboration with families as in the example of Nuri Özaltın 75. Yıl Primary School in Arhavi-Artvin (MEB, 2023). In the following years, universities also cooperate with schools by signing a partnership agreement with the national ministry of education as in the example of Bartın University which implements a special program titled Sustainable Environmental Education: Small Steps Big Touches: Seed Ball and Compost Making (Bartın Üniversitesi, 2022). Narrow collaboration is weakly embedded, and broad collaboration is rarely observed. There was no clear specific wish regarding collaboration in soil (health) education at the primary level.

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Space: Soil (health) education in primary schools in Turkey is primarily conducted *indoors*. In courses that cover soil (health) related topics, learning outcomes or activities that promote *outdoor* engagement is generally absent. The wish is to offer soil (health) education predominantly *outdoors*.

> Children learn better by seeing, hearing, touching and doing. Being indoors, between walls is against human nature"
> *-A university instructor (from interviews).*

Process: The national education programs for primary schools recognize 'learning to learn' as a key competence that education should focus upon, and hence it recognizes the importance of *emancipatory* approaches to education. However, due to a lack of attention and time allocation that would allow for *emancipatory* approaches in courses like Science, Social Sciences, and Life Science where soil (heath) topics are embedded, the *instructive* process remains predominant. The wish is to transition towards a more emancipatory education process.

Activities: In primary education, soil (heath) education is facilitated by predominantly *Knowing-based* activities, with components of *doing-based* activities. *Being-based* activities are generally absent. Public schools that only follow the national education curriculum, typically prioritize knowing-based activities (Ürey and Aydın, 2014). Both public and private schools following TEMA educational programs (TEMA, 2015a and TEMA, 2016) emphasize *doing-based activities*. The wish is to make *being-based activities* predominant or primary education.

Paradigm: A review of soil education resources for primary schools indicates a greater emphasis on the *mechanistic* paradigm, with a specific focus on soil formation, soil contamination, and biodiversity in the soil. The wish is to embrace the *ecological* paradigm.

Gaps, challenges & opportunities

Currently, soil (health) is embedded within different subjects in the national curriculum, albeit, with weak interdisciplinary connections. Lack of specific focus also limits the depth of learning outcomes related to soil (health) topics. The current curriculum also presents soil as a non-living entity, overlooking its ecological significance.

While there is a wish to transition from predominantly *indoor* and *instructive* educational approaches to *outdoor* and *emancipatory* methods, there are several challenges to closing these gaps. First, schools often lack appropriate *outdoor* learning environments and teachers encounter challenges like heavy workloads and insufficient resources. Given the national educational program endorses *emancipatory* approaches, leveraging this policy directive presents an opportunity for curriculum revision that prioritizes teacher empowerment through enhanced opportunities and resources.

Rapid urbanization in Turkey is leading to a further reduction in access to *outdoor* spaces, as well as the reduced opportunities of interacting with soil, consequently, leading to social and cultural barriers to soil (health) education.

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To address these challenges, the curriculum needs revision and restructuring. Alongside, teacher training needs to be adapted to prepare them for transitioning towards these 'wished' forms of teaching as well as to create motivation for adopting the 'wished (*outdoor, emancipatory, being based*)' forms of teaching. There is also a need to collaborate with local authorities and communities to promote awareness of soil (health)'s crucial role in environmental sustainability as well as to establish *outdoor* learning spaces. The complexity of bureaucratic procedures (e.g. for *outdoor* excursions) also needs to be simplified.

> Teachers' lack of motivation. And of course, there is heavy workload and inadequate conditions in schools, and bureaucracy.
> *-An ecological Literacy Teacher Trainer (from interviews).*

Secondary education

Vision: To create a comprehensive and interdisciplinary approach to soil (health) education, fostering a deeper understanding of its significance for sustainability.
Needs: To create conducive conditions for teachers and students by alleviating the pressure of university entrance examinations and enabling teachers via special training focused on emancipatory, experiential, and holistic teaching approaches.
Opportunities: The recognition of collaborative, holistic, emancipatory, and outdoor educational approaches by educational policies presents opportunities to advocate for their enhancement and integration into educational practices.

State and wishes of soil (health) education

Purpose: The secondary education in Turkey includes soil (health) related topics within biology and geography courses but lacks dedicated soil programs. For example, biology courses address soil (health) within ecosystem ecology and plant biology, while geography addresses soil diversity and distribution. In addition, TEMA education programs for secondary education (TEMA, 2015b and TEMA, 2021) which are voluntarily adopted by some schools, offer comprehensive soil (health) related activities that align with the Mission Soil objectives (e.g. reducing soil pollution and enhance restoration, preventing erosion). Most SDGs are embedded in secondary education within and across various disciplines and are likely to address SDG-soil (health) connections, the focus being clearer on SDGs - responsible production and consumption, and clean water and sanitation. For instance, The Lise TEMA education programs (TEMA, 2015b and TEMA, 2021) address the soil, biodiversity, composting (responsible production and consumption), urban gardening (sustainable cities and communities), ecological footprint (climate act), soil problem reporting (partnerships for the goals) with various activities such as Soil Week activities, Meeting with Soil, Land Art. Other SDGs remain weakly embedded in both the national curriculum and two LİSE TEMA educational programs. Teacher competency is suggested to be a crucial factor in connecting soil (health) with EU mission objectives and SDGs. There is a wish to create a major focus on improving soil literacy in society.

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In terms of human development, the Ministry of National Education suggests incorporating the *knowing* and *doing* (e.g. recommends including at least one observation or experiment-based learning in each course), however, soil (health) education predominantly remains focused on *Knowing* about soil (health). While *doing* is weakly embedded in the mainstream curricula, Lise TEMA programs (TEMA, 2015b and TEMA, 2021) place greater emphasis on experiential learning via activities such as composting, and preparing interviews to explore soil (health) related issues. There is a lack of focus on *Being*. The reason for this may be attributed to the fact that students prepare themselves for university entrance examinations which predominantly is based on knowledge-based assessment. The wish is to shift towards an approach to soil (health) education that incorporates all three aspects: *knowing, doing,* and *doing*.

> The university exam system measures what students know, not what they do. ..In 11th and 12th grades, we are working completely towards the exam. Both students and parents see everything else as a waste of time.
> *-A secondary school teacher (from interviews).*

Collaboration: Soil (health) education in secondary schools in Turkey is predominantly *narrow* and occasionally *narrow-broad* with limited involvement of external partners. However, there are interdisciplinary collaborations in teaching which are supported by the national education curriculum. For instance, the Geography coursebook (MEB, 2018b) specifically suggests that teachers from different disciplines should cooperate while preparing teaching materials. Also, a cooperation protocol of TEMA with the Ministry of National Education (MEB, 2019) facilitates the collaboration of TEMA with schools on soil and nature-related topics. The wish is to extend towards *broad* collaboration, with a specific interest in involving different sectors and stakeholders such as farmers, civil society, and agricultural vocational schools.

Space: The national education curricula for the subjects (biology and geography) related to soil (health) education in secondary schools recommend the promotion of *outdoor* activities, they are not compulsory and hence only weakly embedded. Consequently, soil (health) education predominantly occurs *indoors* complemented by few *outdoor* activities (e.g. field trips in Geography lessons). No clear insights on this aspect were gained.

Process: The process is mainly *instructive,* however, recognition of the importance of *emancipatory* approaches is beginning. For instance, the Ministry of National Education has created an activity book for the Biology lesson (MEB, 2020). The wish is to move towards soil (health) education facilitated predominantly through *emancipatory* processes.

Activities: The Ministry of National Education supports *knowing-based* and d*oing-based* activities for secondary education, *doing-based* activities are only presented as a suggestion (e.g. biology curriculum). Consequently, *knowing-based* activities predominate soil (health) education, except for public or private schools that follow the Lise TEMA education programs (TEMA, 2015b and TEMA, 2021) where *doing*-based activities dominate. B*eing-based* activities are weakly embedded. The wish is to adopt an approach where all three: *knowing*, *doing, and being-based* activities are incorporated.

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Paradigm: Soil (health) education within the national curriculum for secondary education dominates the *mechanistic* paradigm. The courses (e.g. geography) focus on educating on specific soil properties and processes (e.g. soil types and composition) with a lack of attention to soil and its role within broader ecological and earth system processes. The wish is to create a shift towards the *ecological paradigm*. However, the Lise TEMA education programs (TEMA, 2015b and TEMA, 2021) already follow an *ecological* paradigm.

> If we can give the ecological perspective to students, they will have a better understanding of how to progress on sustainability."
> -*An* ecology and permaculture teacher *(from interviews).*

Gaps, challenges & opportunities

Due to a lack of specific courses on soil (health) or closely related fields such as agriculture, soil (health) topics are not offered in detail. While the educational policies support the interdisciplinary approach to teaching and advocate for incorporating *outdoor* and *emancipatory* approaches, several practical constraints pose limits to their realization. These constraints include a lack of resources available to schools and necessary ecological knowledge and skills in teachers. Furthermore, during secondary school, preparing for university exams becomes a priority. Consequently, students and parents show little interest in extra-curricular topics and practical learning activities.

To address these challenges, it becomes crucial to address the pressure that students and teachers face in secondary education, potentially by revisiting the criteria for university entrance examinations. In terms of contents, the curriculum itself requires revision to include comprehensive soil (health) education and there is a need to enhance teacher training with greater components of ecological education and skills to facilitate *emancipatory* and *outdoor* teaching. In addition, resources need to be allocated to create suitable *outdoor* learning environments and facilitate more experiential soil education activities.

The national educational program's support for *outdoor, emancipatory, collaborative,* and holistic approaches offers an opportunity for curriculum revision, as well as for teacher empowerment. In addition, expanding engagement and the educational approaches of TEMA and other organizations such as YÖK (Higher Education Council), and TÜBİTAK (The Scientific and Technological Research Council of Turkey) can help close the gaps observed between current and 'wished' states of soil (health) education.

Tertiary education

Vision: To transition towards a holistic approach to soil (health) education that recognizes the diversity of agricultural practices.

Needs: Structural Reforms (especially accreditation system) and resource mobilization to address economic concerns and continued implementation of outcomes of soil (health) education-related initiatives.

Opportunities: There are soil (health) education projects and initiatives that showcase examples where the gap between instructive and emancipatory approaches has been bridged offering valuable lessons to follow.

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State and wishes of soil (health) education

Purpose: At the tertiary level soil (health) education seems to be well embedded. For instance, in undergraduate biology programs, a soil science' course is compulsory (Marmara Üniversitesi, 2022) and in some universities' courses such as ' Healthy Soil, Healthy Future' (Atatürk Üniversitesi, 2022) and 'Soil-Plant Relations' (Uludağ Üniversitesi, 2022) are available as electives to all students (e.g. Uludağ University and Atatürk University). Also, certain agriculture-related courses such as agricultural ecology (Mersin Üniversitesi, 2023a) and organic agriculture (Mersin Üniversitesi, 2023b) are compulsory courses at Vocational Higher Schools of Agriculture and include soil aspects.
These courses primarily focus on soil conservation issues including *reducing desertification*, *conserving soil organic carbon stocks*, *reducing soil pollution, and enhancing restoration*, as well as on biodiversity (*improving soil structure to enhance soil biodiversity*). They also focus on broader SDGs including *zero hunger, good health, well-being, decent work, economic growth, responsible consumption, and production*. There is a weak focus on *improving soil literacy in society* while there is no focus on *reducing the EU's global footprint*. In terms of the SDGs, soil (health) linkages to *sustainable cities and communities* and *quality education* are weakly addressed whereas connections to *gender equality, affordable and clean energy, industry, and innovation* are missing.
In terms of human development, the purpose of soil (health) education varies by faculty or department. In programs where soil-related courses are electives, as well as in faculties like Science and Education, the focus is primarily on acquiring theoretical knowledge (*knowing*). On the other hand, in faculties and vocational higher schools of Agriculture, where soil science courses are compulsory, students engage in both theoretical learning (*knowing*) and practical experience (*doing*), for instance, working in university demonstration gardens. Focus on the aspect of *Being* is rare. One example is the Soil (Land) Ethic Training Program at Hacettepe University (Hacettepe Üniversitesi, 2023). This is an extracurricular club activity open to all university members.

Collaboration: Tertiary-level soil (health) education was found to have predominantly a *narrow-broad focus.* There are several programs where tertiary level teachers and students collaborate across multiple disciplines, but often also engage with municipalities and adult education centers as well as schools at primary and VET levels. *Narrow* and *Broad* collaborations are less frequent. The wish is to expand towards *broad* collaboration.

Space: The predominant learning space for soil (health) education at the tertiary level varies by faculty or department. When these courses are offered as electives, they are primarily offered *indoors*. However, in faculties, and vocational higher schools of agriculture, where soil (health) related topics are compulsory, both *indoor* learning and *outdoor* teaching are common. The wish is to promote *outdoor* learning.

Process: Preference for *instructive* or *emancipatory* processes depends on factors such as course status (compulsory or elective), duration (semester or yearly), inclusion of internships, instructor motivation, and the institution's capacity and resources. However, the soil (health) education primarily relies on *instructive* processes. E*mancipatory*

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processes are weakly embedded. An example is at Gümüşhane University's Kürtün Vocational School of Forestry and Forest Products, where a compulsory Soil Science course requires students to perform their research (Gümüşhane Üniversitesi, 2023). The wish is to facilitate soil (health) education predominantly via *emancipatory* processes.

Activities: At the tertiary level of education in Turkey, soil (health) education primarily emphasizes *knowing-based* activities, particularly in the courses where soil (health) topics are elective. In courses where soil (health) topics are compulsory, a combination of *knowing-based* and *doing-based* activities is common. *Being-based* activities are rare. No insights into the wishes on this aspect were gained.

Paradigm: Both *mechanistic* and *ecological* paradigms are present in tertiary-level soil (health) education in Turkey. For instance, courses offered by the Soil Science and Plant Nutrition, Biology, and Biology Teaching departments take a *mechanistic* paradigm and focus on providing basic disciplinary information (e.g. soil formation). However, mandatory related courses e.g. 'agricultural ecology' and 'organic agriculture' courses, in vocational higher schools predominantly follow the *ecological paradigm*. For example, *the* Agricultural Ecology Course (Mersin Üniversitesi, 2023a) focuses on broader agro-ecosystems topics promoting environmentally sensitive decision-making, and understanding the impacts of environmental factors on plant growth. The wish is to transition towards an *ecological paradigm*.

Gaps, challenges & opportunities

Due to the diversity of courses and programs available at the tertiary level, the identification of broad gaps proved to be challenging based on desk research alone and were identified based on interviews and focus groups.

At the tertiary level, there is a strong emphasis on the institutional accreditation program (KAP). It is an external evaluation method that enables the evaluation of quality assurance, education training, research and development, social contribution, and management system processes in higher education institutions within the scope of the "planning, implementation, controlling, and taking measures" cycle. KAP is carried out by the evaluation teams established by the Higher Education Quality Council within the scope of Institutional External Evaluation and Accreditation Criteria and Institutional External Evaluation and Accreditation Guidelines). This resulted in uniformity in training programs, neglecting the diverse array of agricultural practices and the critical role of soil (health) within ecosystems. Moreover, limited access to resources poses a significant challenge, hindering the collaborative efforts of civil society organizations and individuals to address common goals effectively.

In Turkey, economic priorities often overshadow environmental and soil (health) concerns among farmers, particularly in regions heavily reliant on agriculture for livelihoods, exacerbated by recent events of major earthquakes. This economic emphasis, coupled with a lack of supportive government policies and resources, impedes the implementation and dissemination of soil conservation strategies. Additionally, while there are projects and initiatives focused on soil (health) and related activities, their impact does not continue beyond the project period. Therefore, there is a need to encourage and facilitate sustained,

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long-term efforts beyond specific projects. In addition, there is a need to nurture enthusiasm in teachers.

Addressing these gaps and challenges demands a multifaceted approach. This includes structural reforms (e.g. revisiting the accreditation system) for prioritizing holistic perspectives and sustainable practices, as well as increased support from governmental and non-governmental entities. Moreover, efforts to elevate the significance of soil (health) within agricultural education and practice are vital for ensuring long-term environmental sustainability.

Vocational educational training (VET)

Vision: To adopt a holistic approach to soil (health) education that combines agricultural objectives with ecological understanding and ethical considerations for long-term soil (health).

Needs: To Integrate holistic approaches to soil (health) education in VET programs, encompassing ecological functions and ethical considerations surrounding advanced agricultural technologies.

Opportunities: The existing TOPRAK TEMA program, which emphasizes the cultural and sustainability aspects of soil (health), can serve as an inspiration and a valuable resource to enrich the current curriculum.

State and wishes of soil (health) education

Purpose: the National Ministry of Education in collaboration with the Ministry of Agriculture revised the curriculum for vocational education in Turkey. Implementation of this new curriculum began in 2022. While the new curriculum removed the previously taught courses where soil (health) was predominantly covered (e.g. Soil and Plant and Fertilization), the updated curriculum has included more field-word oriented courses on soil (health) topics (e.g. Preparation for Agricultural Production). This revised curriculum focuses strongly on the agricultural context and on *conserving soil organic carbon stocks* and *improving soil structure to enhance soil biodiversity*. The soil (health)-SDG connections are addressed indirectly, with a specific focus on *life on land*, which is implicitly covered in the curriculum along with *responsible consumption and production*. In addition, an educational program titled 'Toprak TEMA' (TEMA, 2022) provided by TEMA addresses soil (health) related issues in depth and focuses on all the EU mission objectives except for *reducing the EU global footprint on soils*. 'Toprak TEMA' is available for free and is implemented by some agricultural vocational high schools voluntarily. Erosion is an important issue in Turkey, so even if it is not included as a subject in the textbooks, it is assumed that *preventing erosion and reducing desertification* are mentioned in the practical lessons. Toprak TEMA also addresses the connection of soil (health) with many SDGs (e.g. *climate action* and *responsible consumption and production*, broader socio-economic SDGs, e.g. *no poverty* and *decent work and economic growth)*. Interestingly SDGs such as *zero hunger* is missing from either course in

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addition to other broader socioeconomic SDGs (e.g. *industry, innovation and infrastructure* and *peace, justice, and strong institutions*).

In terms of human development, soil (health) education in VET focuses on *knowing* and *doing*. Soil (health) education at the VET level is primarily offered by agriculture-themed vocational high schools which aim to train the farmers for the future, and there is a focus on knowledge acquisition as well as skill development. *Being* is weakly embedded. An example is the course 'My faithful beloved' of the Toprak TEMA education program which focuses on the meaning of soil for Turkish society using artistic approaches including poetry, folk songs, literature, history, and cultural heritage. No insights into the wishes for these aspects on purpose for soil (health) education could be gained.

Collaboration: Collaborations in Soil (health) education in VET in Turkey are predominantly *narrow-broad*. VET schools where soil (health) education is offered often engage in internships, projects, competitions, agricultural activities, or social responsibility projects and therefore the students and teachers frequently engage with parents, local communities, laboratories, and business organizations (local, national, and international). However, VET and university collaborations are less common. One example is the close collaboration between Tokat Gaziosmanpaşa University and an agricultural vocational high school that shares campus, resources, and knowledge, e.g., a university lecturer teaching at VET (TOGÜ MTAL, 2024). *Narrow* collaborations are weakly embedded, and *broad* collaborations are quite common.

> Collaborating in a spirit of dialogue: we avoid the arrogance of practitioners and the arrogance of theorists
> *–A VET representative (from interviews).*

Space: Most soil (health) education-related VET programs are designed to take place both *indoors* and *outdoors*. These courses include *outdoor* practical lessons that accompany the *indoor* lessons (classrooms and laboratories). No insights into the wishes on this aspect were gained.

Process: In soil (health) education-related VET programs, both *instructive* and *emancipatory* processes are present. For instance, one of the learner outcomes in the educational program provided by the national education encourages students to take ownership of their learning by designing and carrying out projects independently, including making their own decisions (MEB, 2023).

Activities: The VET education in Turkey is primarily facilitated by a combination of *knowing*- and *doing-based* activities, however, doing-based activities are dominant in the case of agriculture-oriented VET. Students gain knowledge of processes and factors that affect soil (health) predominantly to agriculture (e.g. soil nutrient status) as well as apply their knowledge and skills (e.g. cultivating soil for croplands, applying machinery on soil). There are only a few examples of *Being-based* activities (e.g. Toprak TEMA program). The insights gained from interviews indicated that students and teachers were satisfied with the focus on *doing-based* activities, and these activities also facilitated gaining a connection with the soil therefore despite no specific focus on *being-based* activities, a focus on being emerged.

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Paradigm: In VET programs, soil (health) education is approached predominantly from a mechanistic paradigm as evident in the learning outcomes of the curriculum which focuses on specific properties and processes of soil and is limited to the context of agricultural production. *Ecological* paradigm is missing from the core curriculum and is weakly present in the extracurricular Toprak TEMA Program which addresses the complex interactions of soil with the broader ecosystem and human society. The wish is to follow a combination of *mechanistic* and *ecological* paradigms.

Gaps, challenges & opportunities

> In Turkish society, there is the concept of mother soil. The most important reason for this is that the soil symbolizes productivity. There is a large population in this country, and to feed this population, the soil must continue to produce. To continue production, the soil must be healthy. *–A VET representative (from interviews).*

Due to the prominence of the agriculture sector in Turkey, soil (health) education at the VET level primarily targets increased agricultural productivity. However, this approach neglects the wider ecological role of healthy soil and its importance for sustainable development. Interestingly, farming is not a preferred career, thus creating a social undervaluing of agricultural education and pro-soil (health) practices. This, along with resistance to adopting new practices, hinders students from applying the innovative techniques they learn. While the potential of advanced agricultural technologies is recognized, there's a lack of emphasis and integration of innovative technologies in the curriculum. Additionally, ethical and sustainability concerns regarding these technologies are not well addressed. All these together seem to overlook the long-term consequences on soil (health).

While the recent revision in the curriculum has helped bridge the gaps in certain aspects of educational design (collaboration, learning space, and learning process), there is a need to introduce courses on multidisciplinary approaches towards soil (health). Since there is a major focus on technological advancements it is necessary to embed the ethical considerations around long-term soil (health). In addition, there is a need for a cultural shift and increased awareness among students and their families about soil (health). Additionally, sustainable agriculture should be made a rewarding career, potentially by highlighting success stories and collaborating with industry professionals to create a cultural shift that values soil (health).

General public

Vision: to enhance soil (health) awareness in society by emphasizing the importance of healthy soils in holistic terms that include ecosystem functioning and long-term human sustenance.

Needs: To incorporate being-based activities to foster a deeper, more intrinsic understanding of the role of healthy soils in the ecosystem and their connection to overall human well-being.

Opportunities: Existing collaboration among municipalities, adult education centers, freelance trainers, and businesses on soil (health) courses, presents a model that could be expanded and replicated to enhance public participation and education on soil (health).

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State and wishes of soil (health) education

Purpose: Courses available for the general public do not address soil (health) directly, but I stay implicit within courses (e.g. horticulture and gardening). The most common offers are from municipalities and adult education centers. Though less common, universities and private trainers also offer more specialized courses and workshops. These courses address the EU Mission Soil goal of *improving soil literacy in society.* In addition, several campaigns address *reducing erosion* and *preventing deforestation* - two important soil-related issues in Turkey. Most common to such courses are people who aim to develop related employment skills (e.g. organic farming) thus indicating a prominence of SDGs *no poverty*, *decent work, economic growth*, and *quality education* along with general interest in *responsible consumption and production* and *good health and well-being.* There are dedicated courses for women and refugees indicating connections with *reduced inequalities, and gender equality* (e.g. Fatih municipality in İstanbul). Connections with SDGs such as *climate action* and *life on land* are weakly embedded, while SDGs like *peace, justice, strong institutions,* and *life below water* are missing. The wish is to focus on *improving soil literacy in society*.

In terms of human development, the purpose seems to be *knowing* in numerous online courses (Merkezi Eğitim Kurumları, 2024), and *doing* that can be seen in various training programs/courses organized by municipalities (Çankaya Belediyesi, 2022), botanical gardens (Nezahat Gökyiğit Botanik Bahçesi, 2020), and civil society organizations (Buğday Derneği, 2023 and Yaşam için Toprak Derneği, 2024). Being is absent. The wish is to balance all: knowing, doing, and being.

Collaboration: The soil (health) related education for the general public is predominantly offered through *narrow-broad* collaborations which commonly include municipalities and adult education centers. An example is the municipality and adult education center in Bodrum (Bodrum Belediyesi, 2023), where municipalities assist the adult education centers in publicizing the courses and providing resources such as classrooms, gardens, fields, and greenhouses. These collaborations are often extended by the engagement of freelance trainers and businesses with a focus on ecology and the environment. The wished forms of collaboration are *broad*.

Space: Learning space for soil (health) education for the general public is predominantly *outdoors* and it is generally offered in fields and gardens. The *indoors* is weakly embedded through online courses, which presumably were predominant during the pandemic period. The wish is to have both *indoor* and *outdoor* components.

Process: Soil (health) awareness offers for the general public are generally facilitated through a combination of both *instructive* and *emancipatory* processes. Irrespective of whether they are offered by municipalities or adult education centers, or by private institutions (e.g. a botanical garden) and irrespective of how basic or specialized the courses are, most of these offer instructions (e.g. on gardening) as well as hands-on practical and *emancipatory* learning. The wish is to continue with the current approach with components of both *instructive* and *emancipatory* processes.

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Activities: In soil (health) awareness offered for the general public, a combination of *Knowing-based* and *doing-based* activities is adopted. There are several knowledge-oriented books available to the interested audience on topics related to soil (health) such as Toprak-Uygarlıkların Erozyonu by David R. Montgomery and Petrol Değil Toprak by Vandana Shiva, in addition to courses such as Applied Horticulture Course (BAÇEM, 2024) that comprise *knowing-* and *doing-based* activities. *Being-based* activities are weakly embedded and are addressed in some books (e.g. Haktanır, 2024) and some YouTube videos (e.g. TEMA Vakfı, 2016). The wish is to adopt activities that combine all three: *knowing-, doing-*, and *being-based* activities.

Paradigm: Soil (health) awareness allows the general public to adopt both *mechanistic* and *ecological* paradigms. An example of a dominant *mechanistic paradigm* is Applied Gardening Course Content by Nezahat Gökyiğit Botanik Bahçesi (Nezahat Gökyiğit Botanik Bahçesi, 2020), which aims at providing an understanding of specific aspects of gardening (e.g. soil care, potting soil and growing plants in pots). There is a growing interest of young people in organic farming, particularly post-pandemic which has led to courses that adopt more an *ecological paradigm*. For example, the 'Onarici Tarim Programı' (Yaşam için Toprak Derneği, 2024) provides training on regenerative agricultural practices and includes soil and water resources along with biodiversity, climate crisis, farmer welfare, and consumer and ecosystem health. No insights into the wishes on this aspect could be gained.

Gaps, challenges & opportunities

Current offers on soil (health) education for the general public are offered in connection with gardening and horticulture, with soil (health) being not the main and specific focus. While it is not practical and not recommended to make soil (health) as the sole focus, it is necessary to enhance the understanding of the connection between soil and ecosystem functioning and long-term human sustenance. Additionally, the restricted resources of the course providers (e.g. small practice areas that do not allow an emancipatory approach) and time constraints (e.g. short-term courses provided by municipalities as free of charge) limit the long-term participation of the public. In these offers, *doing-based* learning is strongly present, still, older farmers seem to remain less engaged and struggle to transition from traditional practices. Moreover, the Farmer Registration System does not mandate formal training or certification and thus there is no system to allow for implementing innovative and pro-soil(health) practices.

To address these gaps, there is a need to encourage and facilitate collaboration among key stakeholders, such as farmers, universities, chambers of agriculture, and NGOs in addition to emphasizing practical training methods, especially among younger farmers who are more receptive to new practices. Implementing mandatory training and certification for farmers within the registration system could ensure they possess the necessary expertise, ultimately leading to improved agricultural outcomes. Alongside this, increasing the number of urban hobby gardens can boost the interest and participation of the public in soil (health) related courses.

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A.15. United Kingdom

In the UK, soil (health) education exhibits significant variation across educational levels, each characterized by distinct current practices and wishes for educational frameworks. There are also slight variations across each of the UK's four nations, as education is a devolved matter with governments in England, Northern Ireland, Scotland, and Wales each responsible for their respective education systems. This has implications for primary and secondary level in particular. However, the insights provided here are viewed as relevant and applicable across the UK in full.

Beginning with foundational understanding at the primary level, soil (health) education advances to more specialized disciplinary knowledge with a sustainability focus in secondary education. At the tertiary and VET levels, it becomes increasingly specialized, emphasizing skills relevant to professional practice. Throughout these educational stages, soil (health) education predominantly emphasizes knowledge acquisition (*knowing)* through traditional classroom settings and *instructional* processes. At the primary level, external organizations like the British Society of Soil Science are the main providers of soil (health) educational materials, integrated within broader topics such as biodiversity and food production. In secondary education, soil (health) concepts are integrated into subjects like geography, environmental science, and biology, with particular relevance to sustainability issues and challenges. At the tertiary level, soil (health) education becomes more interdisciplinary, integrated into courses spanning environmental sciences, agriculture, and related fields. This level aligns closely with a broad range of Mission Soil objectives and SDGs, emphasizing advanced theoretical knowledge, practical applications through field studies and research, and critical perspectives on soil (health)-related issues. VET programs emphasize practical applications in sustainable land management and agriculture, fostering skills development that implicitly addresses most SDGs. Soil (health) education initiatives for general public utilize various media formats and primarily aim at providing foundational knowledge through accessible resources like videos, articles, and activities. Despite the availability of public education resources on soil (health), their effectiveness and reach remain uncertain.

Across all educational levels, there is a wish to integrate SDGs more deeply in soil (health) related courses. There is a general wish to integrate *knowing-, doing-,* and *being-based* activities (at primary, secondary, and tertiary levels) for deeper engagement. Furthermore, strengthening an *ecological paradigm* emphasizing the interconnectedness of soil (health) with broader ecological and human systems emerged as a common wish along with broadening collaborations with external stakeholders.

> As a person who is involved in research and science, we might talk something complicated, but actually we need to simplify it to the little learners, to the educators, and who are not scientists, because it's very simple
> *- A PhD student (from interviews).*

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Primary education

Vision: To transition towards *outdoor* and *emancipatory* soil (health) education through experiential, hands-on learning that recognizes the role of soil (health) in broader ecosystem and societal systems functioning.
Needs: To enable teachers in implementing the envisioned educational design for soil (health) education through specialized training, support and allocation of required resources (outdoor spaces and/or the means to access them, educational resources designed for emancipatory learning, through doing and being-based activities).
Opportunities: There are examples such as eco-schools, which exemplify envisioned educational designs in the context of environmental education which can be expanded to include soil (health).

State and wishes of soil (health) education

Purpose: Soil (health) education in primary schools in the UK is limited in both scope and practice. There is little evidence to suggest that soil (health) topics are included in the formal primary school curriculum and are generally offered by external organizations such as the British Society of Soil Science. Soil (health) topics are typically integrated into broader topics such as plant studies, biodiversity, and food production, rather than being treated as a standalone subject. For example, educational materials often focus on soil fertility for plant growth (e.g., Bebbington et al., 2016) and recognizing soil biodiversity as an indicator of soil (health) (Natural History Museum, n.d.). These educational offers align with Mission Soil objectives of *improving soil literacy in society* and *improving soil structure to enhance soil biodiversity*, as well as, to a degree, *conserving soil organic carbon stocks* (e.g. BBC, 2023), *stopping soil sealing and increase re-use of urban soils* (e.g. British Society of Soil Science, 2023a), *reducing soil pollution and enhance restoration,* and *preventing erosion* (e.g. British Society of Soil Science, 2023b). However, there is little-to-no evidence indicating that goals such as *reducing desertification* and the *EU's global footprint on soils* are embedded within the primary curriculum. These educational offers do not explicitly mention SDGs, however, the connection between soil (health) and certain SDGs, most notably *Life on Land*, is implicit, albeit with limited scope. For instance, there are exercises where primary school students engage in counting and identifying worms present in the soil (British Society of Soil Science, 2021a). Other SDGs are found to be missing. The wish is to enhance soil literacy among primary school children that foster a connection, respect, and curiosity that can be further developed in secondary education. There is no explicit wish for integrating any specific SDG within soil (health) at primary education level.

In terms of human development, the purpose of soil (health) education primarily is *knowing*, followed by *doing* which is also well embedded. For instance, the Science and Plants for Schools 'Investigating Fertilisers' resource (Science and Plants for Schools, 2022a) includes components where students learn to prepare soil for plant growth. The purpose of *being* is apparently weakly embedded however, there are examples where the purpose of *being* potentially emerges resulting from *doing* focussed learning. For

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example, in the Manchester Environmental Education Network's 'Save Our Soils' program, students actively work to enhance growing conditions for plants on the school site, encouraging development of personal relationship and a sense of responsibility for caring for soil (*being*) (MEEN, 2020). There is a strong wish to strengthen the purposes of *doing* and *being* that encourage primary school students.

Collaboration: Educational resources related to soil (health) are largely developed by external organizations, such as the British Society of Soil Science, which often adopt an interdisciplinary approach (*narrow-broad* collaboration). However, these courses are not mainstream and are usually delivered by primary teachers in a traditional teacher-student collaborative format (*narrow*). Consequently, *narrow* collaborations remain predominant while *narrow-broad* collaborations remain weak. *Broad* collaborations were found to be missing. There was no clear specific wish regarding forms of collaboration in soil (health) education for primary level, however there was a wish expressed that would allow for funding soil (health) focussed and related programs.

Space: Soil (health) education in primary schools in the UK is primarily conducted *indoors* and include resources such as books, information sheets, online resources and videos, as well as some experiments that brings the soil inside classrooms (e.g. experiments testing the water retention rates of different soils) (British Society of Soil Science, 2022a), and using microscopes to investigate soil samples. *Outdoor* education is weakly embedded and includes activities such as identifying and counting worms in soil (British Society of Soil Science, 2021a). There is a wish is to strengthen *outdoor* education to compliment indoors education for soil (health).

> Getting children interested early on is crucial. How many kids in primary school actually go out and plant things in the garden, get messy there, and so they're in touch with it? It's as if education doesn't support them to take them on that journey.
> *- A lecturer and soil scientist (from interviews).*

Process: Soil (health) education for primary schools in the UK is primarily facilitated through *instructive* processes. For instance, worksheets or posters are used to explain soil functions (British Society of Soil Science, 2023c) and practical activities/experiments are used to develop an understanding of soil's role in plant growth (Science and Plants for Schools, 2022b), and in both examples pre-defined learning and learning outcomes are guided by teachers. *Emancipatory* approaches to education are weakly embedded. For example, Natural History Museum offers a Key Stage 2 (ages 7-8) resource where students work in groups to observe, discuss, and report on soil samples from their surroundings (Natural History Museum, n.d.). The wish is to strengthen *emancipatory* processes in soil (health) education to foster curiosity and engagement with soil.

Activities: In primary education, soil (heath) education is facilitated by predominantly *Knowing-based* activities, which is often complimented by *doing-based* activities to reinforce the knowledge. These *doing-based* activities are generally designed for one time usage and not directed towards skill development. An example of doing-based activities includes experiments related to planting or observing worms and soil life, which often come with worksheets to help students learn from the experience (British Society of

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Soil Science, 2021a). In such courses, students might learn about how soil affects plant growth through activities, but these activities might not actually teach them how to grow healthy plants in that soil. Similarly, observing worms or other signs of healthy soil might help students understand soil biodiversity, but it might not teach them how to improve the soil (health) themselves. *Being-based* activities were found to be absent. The wish is to increase *doing-based activities* as they were considered essential for effectively engaging students with soil (health) issues.

Paradigm: A review of soil education resources for primary schools indicates a greater emphasis on *mechanistic* paradigm, with specific focus on scientific learning about the importance of soil for plant growth and related processes and activities. While it may be assumed that some understanding of how soil (health) relates to human and societal impacts is implicit especially as an outcome of doing-based activities, no evidence of explicit e*cological paradigm* within soil (health) education could be found. The wish is to establish the *ecological* paradigm.

Gaps, challenges & opportunities

Currently, soil (health) education is not embedded in the formal primary education curriculum in the UK, resulting in a lack of structured learning opportunities. Consequently, awareness about soil (health) is low, particularly among urban children who often perceive soil merely as 'dirt' due to limited exposure to natural environments. Educational resources on soil (health) are limited and primarily developed by external organizations such as the British Society of Soil Science. These resources align with a few Mission Soil objectives but do not explicitly address the SDGs. A critical question arises regarding the necessity and appropriateness of integrating information about SDGs and EU mission goals into primary education curricula. Given the young age of primary school students, it might be more effective to focus on developing foundational knowledge about soil (health) before introducing broader concepts like the SDGs and EU mission goals.

There are wishes to transition from predominantly *indoor, instructive* approaches rooted in a *mechanistic paradigm* to incorporate more *outdoor, emancipatory* education aligned with an *ecological paradigm*. However, such shifts face significant challenges. These include logistical hurdles such as securing suitable outdoor spaces for learning, particularly in urban environments, as well as navigating curriculum requirements that are primarily designed for indoor instruction. In addition, teachers face time constraints and prioritisation of learning outcomes that are mandated in the curriculum, which further restricts opportunities for open, emancipatory learning processes. Moreover, there is a need for specialized teacher training to effectively facilitate outdoor, emancipatory learning experiences that encourage student-led exploration and discovery. Overcoming these challenges requires collaborative efforts among educators, policymakers, and community stakeholders to advocate for

> Not only do they [schools] not have soils, but they don't even have a budget to get them a minibus to come out. So even two miles away, you can't get them to where the kid can experience it [soil].
> *-A civil society representative and farmer (from interviews).*

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flexible educational frameworks that support experiential learning and foster a deeper ecological understanding among students.
There are examples of collaborative initiatives between educators, NGOs, and environmental organizations which offer opportunities to enhance soil (health) education that aligns at least partially with the wished educational design elements. Such initiatives need financial support and opportunities for expansion.

Secondary education

Vision: To transition towards soil (health) education that follows an integrated purpose of *knowing, doing* and *being*, and fosters understanding on various aspects of soil (health) as well as on its interconnectedness with broader ecological and human systems facilitated by *instructive* and *emancipatory* processes.
Needs: To revise current curriculum to make soil (health) more explicit and support implementation of the envisioned pedagogical approaches.
Opportunities: Existing initiatives, such as the British Society of Soil Science's #Grounded project, exemplify the envisioned educational design elements and can serve as inspiration for developing and expanding soil (health) education initiatives.

State and wishes of soil (health) education

Purpose: The secondary education curriculum in UK includes soil (health) related topics within geography, environmental science and biology courses. In general, most of these courses predominantly address the EU Mission Soil goal of *improving soil literacy in society*. In addition, soil (health) components within these courses also address soil formation, structure and relevance for other EU mission goals such as *conserving soil organic carbon stocks* (e.g. Pearson Education Limited, 2016), *preventing erosion* (e.g. AQA Education, 2019); and *improving soil structure to enhance soil biodiversity* (e.g. AQA Education, 2016). In addition, these courses weakly address soil compaction and thus partially address *stopping soil sealing and increase reuse of urban soils*. Other EU mission goals might be assumed to be implicit within subjects such as environmental science, even though they are not explicitly addressed. There are a few resources, such as the #Grounded project by British Society of Soil Science (n.d.), targeted at secondary education and addressing several of EU mission goals (*conserving soil organic carbon stocks; stopping soil sealing and increase re-use of urban soil; reducing soil pollution and enhance soil restoration; preventing erosion, improving soil structure to enhance soil biodiversity;* and *improving soil literacy in society*), however these are not widely implemented.

Secondary education brings sustainability into discussion, however its relationship with soil (health) is not explicitly presented. Nevertheless, importance of healthy soils for carbon sequestration (*climate action*), supporting food production (*zero hunger*) and supporting *life of land* are well represented, even if implicitly (OCR, 2023; Pearson Education Limited, 2016; AQA Education, 2017). Additional SDGs implicitly covered, albeit weakly embedded, include *clean water and sanitation* and *good health and well-being*,

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which are linked to climate action and food production. Other SDGs like *responsible consumption and production* and *sustainable cities and communities* are also touched upon through educational materials addressing human impacts on soil (health). Other SDGs were found to be absent. The wish is to enhance soil (health) education in general without any expressed wished to focus on specific EU Mission Soil or Sustainable Development Goals.

In terms of human development, soil (health) education is predominantly focused on *knowing* about soil (health) within the context of a specific subject. For instance, when teaching about anthropogenic impacts on nature, the purpose focuses on gaining knowledge about how human activities affect soil fertility, erosion, degradation and what management practices can contribute towards sustainability goals (AQA Education, 2017). *Doing* is weakly embedded and is generally used to strengthen knowledge acquisition. For instance, practical exercises related to soil (health) topics focus on the development of scientific capabilities like techniques for observation and analysis rather than soil management for sustainability. *Being* is further weakly embedded and is most prevalent in subjects like Geography and Environmental Science that explore human impact on nature and discuss topics like climate change and biodiversity loss (AQA Education, 2019; SQA, 2021; WJEC, 2019). These subjects sometimes highlight the development of 'citizenship' as a goal, promoting moral values towards the environment, particularly on sustainability topics, although soil (health) is not specifically mentioned. The wish is to shift towards an approach to soil (health) education that has an integrated purpose of *knowing, doing* and *being*.

> In secondary schools, what they [students] get taught is curriculum dependent and that's where soils have both a disadvantage and an advantage.
> The places that I've seen soils really working is where a science teacher, or indeed a biology teacher or a geography teacher or whoever, recognises that they can use soil as a medium to teach a number of topics.
> *-A university lecturer and soil scientist (from interviews).*

Collaboration: Soil (health) education in secondary schools in the UK is predominantly *narrow* and can be attributed to a focus on developing discipline-specific knowledge and capabilities. However, *narrow-broad* collaborations likely emerge from internal (within-school interdisciplinary) collaborations as soil (health) topics are taught under different subjects (Geography, Biology, Environmental Science, etc). Resources developed by external stakeholders and educational organizations like the British Society of Soil Science (British Society for Soil Science, 2023c,d), Royal Geographical Society (Royal Geographical Society, n.d.), and Royal Society of Chemistry (Royal Society of Chemistry, n.d.) demonstrate the potential for integrating soil (health) education into resources addressing climate change, sustainability, and biodiversity issues. Nevertheless, no evidence could be found that indicate adoption of these collaborations in secondary education, suggesting they are only weakly embedded. *Broad* collaborations are also weakly embedded or absent. The wish is to develop and facilitate more soil (health) related education irrespective of any specific form of collaboration.

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Space: Soil (health) education predominantly occurs *indoors* and includes typical knowledge acquisition activities (e.g. from textbooks) as well as practical exercises that are designed for classroom-based delivery. *Outdoor* activities are expected within certain subjects, although these are weakly embedded. For instance, AQA stipulates a minimum of four days of fieldwork at A-Level for Environmental Science to enhance practical skills (AQA Education, 2016). However, no information could be obtained to what degree this includes the study of soil (health). The wish is to increase the *outdoor* learning component.

Process: The process is mainly *instructive,* which may be attributed to the focus on pre-defined learning outcomes outlines in the subject guides and specifications reviewed, as well as the emphasis on formal examination for student assessments. Even subjects like Environmental Science, which seem well-suited for investigative learning about social-ecological sustainability, emphasize "clearly defined learning outcomes" for practical work (AQA Education, 2017). *Emancipatory processes* are weakly embedded and appear to be largely limited to investigative and observational approaches, and teaching of relevant techniques (e.g., how to run experiments). For instance, in A-Level Geography assessment, students conduct independent investigations on a topic of choice (OCR, 2023). However, the objective here is to evaluate their investigative technique rather than to achieve more open or transformative learning. There are instances of co-design, for instance, in Level 5 Environmental Science within the Scottish education system (senior secondary level), where assessments are designed to complement instructional learning methods. Here, students apply their skills, knowledge, and understanding through conducting experiments or fieldwork procedures, investigating topics relevant to environmental science. However, no evidence could be found that indicates how well soil (health) topics are embedded in such *emancipatory* assessments. The wish is to move towards soil (health) education facilitated through a combination of *instructive* (to enable grasping and developing formative concepts and skills) and *emancipatory* processes (to facilitate and encourage transformative outcomes for students in their understanding of their relationship to soil and the natural world).

Activities: Since learning outcomes are predominantly assessed according to the successful demonstration of knowledge, *Knowing-based* activities predominate soil (health) education at secondary level. These activities focus on learning about key concepts related to soil (health), its importance for ecosystem health and carbon sequestration, and how soil (health) is affected by human activities (Pearson Education Limited, 2016:9). *Doing*-based activities, although weakly embedded, include conducting laboratory-based experiments and some investigative projects, especially at higher secondary education. *Being-based* activities are not explicitly embedded, however may likely emerge as a (limited) consequence of *doing-based* activities. The wish is to adopt an approach where all three- *knowing-*, *doing-, and being-based* activities are incorporated.

Paradigm: A *mechanistic paradigm* is dominant in soil (health) education at secondary level, with a focus on fostering understanding of soil structure, soil type, nutrient cycling etc.

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Ecological paradigm is weakly embedded and is almost always limited to acquiring knowledge about interrelationships of soil (health) with flora, fauna, and broader ecosystem functioning. For example, the Environment and Land-based Science GCSE focuses on teaching about the inter-relationships within ecosystems and the anthropogenic impacts on the environment. These activities also have soil (health) components within the context of traditional and alternative methods of food production (OCR, 2013: 8). The wish appears to be to more fully and deliberately incorporate an *ecological paradigm* into secondary education for soil (health).

Gaps, challenges & opportunities

Currently, soil (health) topics are weakly embedded in the formal curricula and are taught within different subjects as specific to their disciplinary context. This, along with the lack of interdisciplinary collaboration to teaching, limits a system-oriented education where the interdependencies of soil (health) and broader ecological and human systems are not emphasised. While there is a wish to transition towards an education design that follows an integrated purpose of *knowing, doing* and *being* facilitated by a combination of *instructive* and *emancipatory* processes with a dominance of *outdoor* learning, achieving this transition faces certain challenges. These challenges include an existing curriculum which is heavily focussed on preparing students for General Certificate of Secondary Education (GCSE) assessment criteria and is already packed with the content that needs to be taught. In addition, focus on knowledge acquisition as the predominant learning outcome leaves limited scope of embedding new topics and for experimenting with new (wished) pedagogical approaches. Furthermore, the logistical challenges such as limited access to suitable *outdoor* learning spaces and relevant educational resources pose additional challenges. To address these challenges, it becomes crucial to address the pressures that students and teachers face in secondary education, potentially by revisiting the criteria for academic assessments. In terms of content, the curriculum itself requires revision to include comprehensive soil (health) topics. Subject areas like Environmental Science, Geography, Chemistry, and Biology provide natural entry points for integrating soil (health) concepts into existing curricula.

> I sit at the back of enough classrooms, and Key Stage 3 [i.e. the first years of secondary education when students are introduced to a wide range of subjects] in my opinion … is just preparation for GCSE [General Certificate of Secondary Education].
> *-A lecturer and teacher-trainer (from interviews).*

Initiatives such as the Grounded project (British Society of Soil Science, 2020) demonstrate effective *doing-based* activities that could be further integrated into formal education settings to enhance students' knowledge, values, and skills related to soil (health) management. Moreover, the growing presence of global issues such as climate change and biodiversity loss within formal curricula presents opportunities to engage students more broadly in soil (health) issues and foster associated knowledge and skills development.

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Tertiary education

Vision: To transition towards a multidisciplinary systems approach to soil (health) education through integrated *knowing-, doing-* and *being-based activities*.
Needs: To develop new soil (health) focused courses and enhancing existing ones across disciplines, while prioritizing *outdoor* learning, revising assessment methods to include *being-based* and *emancipatory approaches*, and fostering collaborations with NGOs.
Opportunities: There are educational programs (e.g. Goldsmiths University of London's Art, Ecology, and Social Justice program) that show how to leverage interdisciplinarity to achieve *being*-focussed and emancipatory education on soil (health) topics. Such programs offer an opportunity that may be capitalized for realising the envisioned soil (health) education.

State and wishes of soil (health) education

Purpose: At the tertiary level soil (health) education in UK is integrated into different disciplines and courses and is therefore mainly taught within a discipline (Environmental Sciences, Geography, Agriculture, Food Sciences, Ecology, Chemistry, etc.) specific context. There is currently no 'Soil Science' course offered at undergraduate level and only one offered at master's level (University of Aberdeen) – though another is due to begin at Cranfield University in September 2024. Therefore, the extent to which the Mission Soil objectives and SDGs that are addressed also depend on the learning pathway and disciplinary focus of the related courses. Nevertheless, the relevant course content delivered across these disciplines appears to align with the EU mission goals of *conserving soil organic carbon stocks; reducing soil pollution and enhance restoration; preventing erosion; improving soil structure to enhance soil biodiversity* and *improving soil literacy in society,* with a relatively weak focus on *stopping soil sealing and increase re-use of urban soils*. There was less evidence found to suggest that goals of *reducing desertification* and *reducing the EU global footprint on soils* are represented. At tertiary level, the relevance of soil (health) for sustainability goals are presented very clearly and specific SDGs are mentioned. In particular, courses address the SDGs of *good health and well-being* and *life on land* (by drawing connections between soil degradation and soil biodiversity), zero hunger (by addressing importance of soil fertility for food production), *climate action* (by focussing on role of healthy soils in the carbon cycle), *sustainable cities and communities* (by drawing connections between soil biodiversity, soil sealing and the environmental impact of human activities) and *responsible consumption and production* (by focussing on the impact of human activities on soil (health)) (Bangor University, n.d.; University of Aberdeen, 2023; Warwick University, 2024). SDGs *clean water and sanitation* and *industry, innovation and infrastructure* appear to be weakly embedded, and are respectively addressed in hydrology (e.g., Imperial College London, n.d.) and sustainable production in agriculture (e.g., Queen's University Belfast, n.d.) courses. There was less evidence that SDGs such as *no poverty, affordable and clean energy* and *reduced inequalities* are represented.

The wishes are for an approach to soil (health) education that places greater emphasis on local and global threats to soil (health), as well as recognizing and promoting an

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understanding of the foundational importance of soil (health) for achieving a wide range of SDGs. This applies to specific soil (health)-based (or soil science) education and where it is delivered within different disciplinary contexts.

In terms of human development, the purpose of soil (health) education is *knowing* and *doing*. This is attributable to the focus on development of professional skills for instance, GIS surveying methods (University of Aberdeen, 2024) and soil management techniques for sustainable agriculture (e.g. Royal Agricultural University, n.d.). The purpose of *being* is weakly embedded, but may naturally emerge from *knowing* and *doing*, particularly as tertiary education encourages systems thinking, especially in fields like Environmental Sciences. The wish for a holistic approach to soil (health) education that incorporates *knowing*, *doing*, and *being*, which will require development in each approach and in *being* specifically.

Collaboration: Soil (health) education at the tertiary level primarily involves *narrow* collaborations, occasionally extending to *narrow-broad* collaborations. Examples of *narrow-broad* collaboration include a Food Science postgraduate course at Warwick University that integrates elements of soil science and involves external experts to enhance professional learning dimensions (Warwick University, 2024); and Agricultural Technology undergraduate course at Queen's University Belfast, where students undertake a 16-week industry placement as part of their studies (Queen's University Belfast, n.d.). While there is a wish to engage collaborations outside university, specific forms of collaboration could not be identified.

Space: The predominant learning space for soil (health) education appears to be *indoors*, primarily in classrooms and laboratories. However, many courses do include *outdoor* components, such as field studies and work placements, which primarily focus on development and application of soil (health) investigation and related techniques that include soil classification, surveying, management, and remediation. For example, the MSc course in Soil Science at the University of Aberdeen has a significant focus on field and laboratory-based teaching (University of Aberdeen, 2024). The wish is to promote *outdoor* learning to benefit learning outcomes and student experience.

> One of the problems is that people only know a little bit. And they know a little bit depending upon what their lecturer in their department are about. I mean the great, the great advantage was there were departments of soil science, if you like, who could put those little bits together into a coherent whole.
> *-A lecturer and NGO leader (from interviews).*

Process: There is predominance of *instructive* processes in tertiary level soil (health) education. The typical process includes explanation of the key concepts of soil (health) and soil science followed by applied learning within a wider scope of the subject (e.g., Agriculture, Environmental Science, Geography, Biology). For example, students at the University of Aberdeen study how soil productivity is influenced using analytical methods and modelling, particularly focusing on greenhouse gas emissions and carbon sequestration to evaluate mitigation strategies (University of Aberdeen, 2023). The wish is to facilitate soil (health) education using a combination of both *instructive* and *emancipatory* processes.

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Activities: At the tertiary level, soil (health) education combines *knowing-based* activities like lectures and readings with *doing-based* activities like experiments and field trips. This approach is designed to equip students with relevant professional skills in soil science, agriculture, horticulture, food science, land management, and applied sciences. For example, the University of Edinburgh's Soils and Sustainability MSc course emphasizes both theoretical understanding and practical skills through varied teaching methods. Students learn about soil formation, functions, and ecosystem services, the role of soil (health) in climate change mitigation, etc., alongside management strategies, soil analysis, and surveying to prepare for careers in land-based management and environmental protection (The University of Edinburgh, 2024). *Being-based* activities are very weakly embedded. The master's program in Art, Ecology, and Social Justice at Goldsmiths, University of London (n.d.) presents an interesting example of how interdisciplinarity can embed *being-based* activities. This course supports artists working with media such as painting, sculpture, and digital media, and engaging in practices like food production, sustainable data, citizen science, re-wilding, inter-species care, somatic work, and ritual. The apparent wish is to facilitate soil (health) education using a combination of all three *knowing-, doing-* and *being-based* activities.

Paradigm: A *mechanistic* paradigm is predominant in tertiary level soil (health) education. *Ecological paradigm* is weakly embedded, but is notably present in the subjects that take a more systems-level approach to education on sustainability, like Environmental Science and Geography in particular. For instance, Bangor University's first-year Environmental Science BSc module 'Earth Systems and Processes' makes explicit reference to learning outcomes that 'Demonstrate an understanding of the inter-relationship of processes occurring within earth systems' (Bangor University, n.d.). The wish is to approach soil (health) education from integrated *mechanistic* and e*cological paradigms*.

Gaps, challenges & opportunities

Currently, there is lack of educational programs that specifically focus on soil (health), rather soil (health) topics are integrated into various disciplines to various degrees. This results in soil (health) being taught through discipline-specific lenses, and a lack of comprehensive systems approach that takes a direct focus on soil (health)'s interrelationships with broader ecosystems and human systems. The wish to transition from predominantly *indoor, instructive* education to more *outdoor* education facilitated through *instructive* and *emancipatory* approaches, integrating *knowing, doing,* and *being-based activities*, faces several academic and administrative hurdles and challenges. Current curricula are primarily designed to emphasize discipline-specific knowledge acquisition and professional skill development, which in turn limit the capacity for developing certain wished

> To re-establish soil science in the UK's tertiary system as a way to teach the fundamentals of soil (health) and the skills required for soil (health) improvement implies the need for more discipline-specific *knowing* and *doing*. Interestingly, this combined approach might also help to facilitate greater *being*-based learning by supporting soil (health) actions and behaviours in interdisciplinary ways within the wider educational context.
> *-A lecturer and NGO leader (from interviews).*

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educational elements such as *being-based* activities, *ecological paradigm* and *emancipatory* approaches in soil (health) education. It may be that these elements are not included where they are not perceived to directly align with assessment and professional requirements. Therefore, there are difficulties (e.g., adding further pressures to student and educator workloads) with integrating these elements within established pedagogical approaches, which may therefore face resistance from educators, students, administrators, and stakeholder industries. Additionally, there is an apparent lack of consensus on key elements of soil education, including approaches to soil classification and definitions of 'healthy' soil. Furthermore, lack of resources such as outdoor learning spaces pose additional constraints, especially in cities and urban areas.

To address these gaps, there is a need to strengthen soil (health) within different courses and potentially establishing new soil (health) focused courses. In addition, there is a need to support outdoor learning by allocating resources and actions to make outdoor spaces assessable, especially in the urban areas, and revisiting academic assessment methods to include a recognition of emancipatory and being based components. Expanding collaborations to include NGOs and other non-industry partners, focusing on co-learning for soil (health), would enrich the educational experience.

Given its relevance to daily life and societal challenges, soil (health) is an ideal subject for integrating the educational purposes of *knowing, doing*, and *being*, as well as where *emancipatory* processes can effectively be experimented, as exemplified in Goldsmiths University of London's Art, Ecology, and Social Justice program where interdisciplinarity and being based activities are intertwined. By capitalizing on such opportunities, the educational approach to soil (health) can be greatly enriched, effectively addressing existing gaps and future educational needs.

Vocational educational training (VET)

Vision: To expand knowledge on soil (health) education and encourage broad collaborations beyond traditional sectors, and integrate ecological perspectives to address global sustainability challenges.
Needs: to make soil (health) education more comprehensive and connect it with the application-oriented focus of VET courses.
Opportunities: The ongoing programs that demonstrate the envisioned educational design of soil (health) education, such as Cranfield University's new Apprenticeship/MSc in Soil Science and the Soil (health) Nutrient Health scheme in Northern Ireland, can serve as an inspiration and a valuable resource to enrich the current curriculum.

State and wishes of soil (health) education

Purpose: There is a significant focus on soil (health) at the VET level, with an emphasis on soil structure, fertility, pollution, and erosion, mainly within the context of sustainable land management, agriculture, horticulture, forestry, and arboriculture. These courses primarily align with Mission Soil objectives of *preventing erosion, reducing soil pollution and enhance restoration, conserving soil organic carbon stocks,* and *improving soil structure*

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to enhance soil biodiversity. For example, each of these goals is addressed in the unit 'Plant and Soil Science' — a core module in a range of vocational courses focused on land management (Pearson Education Limited, 2020a). EU mission goals like *stopping soil sealing and increase re-use of urban soils* (within the context of productivity impacts of soil compaction (e.g. OCR, 2016) and *improving soil literacy in society* are weakly embedded, while there was no evidence that *reducing desertification* and *reducing the EU global footprint on soils* are currently represented. The VET courses related to soil (health) address most of the SDGs, albeit implicitly. Most notably, the SDGs *zero hunger, responsible consumption and production*, *life on land* and *climate action* are strongly embedded. *Decent work and economic growth*, *quality education*, *industry, innovation and infrastructure*, and *good health and well-being* may be viewed as implicit to the process of equipping trainees and upskilling professionals/practitioners with soil (health) education. *Sustainable cities and communities* are weakly embedded at the VET level, possibly due to the VET's primary emphasis on vocations linked to rural economies in the UK. SDGs that include *no poverty, gender equality*, and *peace, justice, and strong institutions* appear to be absent. The wish is to expand the knowledge about soil (health) to make it more comprehensive without restricting it to specific EU mission or sustainable development goals.

> Soils, because they're so pervasive, means that the course needs to be broad. But at the same time not losing that depth [disciplinary focus] *-A tertiary level and VET lecturer (from interviews).*

In terms of human development, soil (health) education at VET level focuses on *knowing* and *doing*, which may be understood as a consequence of an educational focus on knowledge acquisition as well as skill development deemed necessary for associated vocations. *Knowing* focuses on concepts and principles of plant and soil science (e.g. Pearson Education Limited, 2020a) and forms a basis for *applying* skills (*doing)* such as farming practices to improve soil (health) (OCR, 2016), erosion control measures (Cranfield University, 2024), and adding organic matter to soil for soil (health) (Bennet, n.d.). *Being* is weakly embedded, however it is assumed to emerge as a consequence of learning and practicing sustainable soil management. No insights the wishes for purpose for soil (health) education in terms of human development could be gained.

Collaboration: Collaborations in soil (health) education in VET in UK are predominantly *narrow* and *narrow-broad*, which often depend on the nature of the course. An example of *narrow* collaboration is where trainee farmers at agricultural colleges (e.g. College of Agriculture, Food and Rural Enterprise (CAFRE) in Northern Ireland or Scotland's Rural College) gain practical agricultural skills on campus and during work experience (CAFRE, n.d.a). On the other hand, a higher Level 3 Apprenticeship Diploma in Agriculture integrates training and assessment at multiple campuses, hence *narrow-broad* collaboration (CAFRE, n.d.b). *Broad* collaborations are rare. The wish is to have more *broad* collaborations, specifically to assist land managers to improve soil (health).

Space: Most soil (health) education related VET programs are designed to take place both *indoors* and *outdoors*. In general students learn about the concepts, principles, and

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techniques of soil (health) and management *indoors*, in classrooms and laboratories. These are complimented with practical observation and applied learning during *outdoor* practical lessons and application in the field (Pearson Education Limited, 2021: 7). There is a wish to maximise *outdoor* learning where possible.

Process: Soil (health) education related VET programs are primarily *instructive,* particularly at earlier stages of training, where the focus is on developing knowledge of core concepts, principles, and processes. *Emancipatory processes* are weakly embedded, although there are instances where more open and collaborative learning is encouraged. For instance, in a Pearson BTEC unit on Organic Agricultural Production, tutors guide learners in land-based subjects through open learning techniques. This includes activities such as creating crop rotations and discussing non-chemical pest control methods to promote soil (health) and sustainable agriculture (Pearson Education Limited, 2020b:7). The wish is to strengthen and include both *instructive* and *emancipatory processes* that contribute to improving soil (health) specifically.

Activities: VET education in UK is primarily facilitated by a combination of *knowing-* and *doing-based* activities. Students gain knowledge of processes and factors that affect soil (health) in relation to associated subjects that include agriculture, horticulture, land management, arboriculture, etc. In addition, they test their knowledge and develop and apply techniques as the basis of their ongoing professional development. For instance, in the Higher National Certificate (HNC) in Horticulture at Scotland's Rural College (n.d.), learners must integrate their understanding and practical skills in soil management, plant growth, physiology, and nursery production to develop their own outdoor plot as part of their final assessment. The wish is to facilitate soil (health) education by a combination of *knowing-* and *doing-based* activities.

Paradigm: In VET programs, soil (health) education is approached predominantly from a *mechanistic* paradigm, focusing on specific soil science concepts and practices in a neutral, objective, and rational manner. This approach emphasizes predefined knowledge outcomes related to soil types, its physicochemical properties, and biological activities affecting soil (health) and fertility (Pearson Education Limited, 2021; Buckingham et al., 2018). An *ecological* paradigm is weakly present. For instance, in the Pearson BTEC unit specification for Organic Agricultural Production, tutors are instructed to cover environmental impacts, including how cultivars in crop rotations can positively influence local flora and fauna to enhance wildlife habitats (Pearson Education Limited, 2020b:2). The wish is to strengthen the *ecological* paradigm.

Gaps, challenges & opportunities

Currently, soil (health) education at VET level in the UK predominantly focuses on local and regional issues like pollution and erosion over global concerns with less regional, and therefore less direct vocational, relevance such as desertification. This creates a gap in linking soil (health) education to global sustainability issues. There is also a potential gap in formally incorporating *being-based* learning methods within VET programs, despite the likelihood of informal and experiential *being-based* learning in rural locations and vocations.

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Limited collaborations with partners outside traditional academic and vocational sectors, such as NGOs and the arts, further restrict enrichment opportunities.
There is a clear need to raise the level of soil education for soil (health)-specific outcomes, and to make it more comprehensive. Notably, there is an apparent lack of consensus around the meaning of the term "soil (health)" and how it can or should therefore be measured and taught. Some interviewees questioned the suitability of the term for practical applications altogether, and suggestions for focusing on increasing "soil knowledge" rather than holistic "soil (health)" concepts were proposed. In terms of educational design, there is a need to develop formal strategies to incorporate *being-based* activities within VET programs, which may be facilitated by creating collaborations beyond traditional academic and vocational sectors to include partners like NGOs and artists. Furthermore, given the focus on applied education in VET, it would be necessary to demonstrate the interconnectedness of soil (health) with broader public goods and advocating for its positive impact on sustainability and societal well-being.

> What is happening at the moment is debate is very polarized. It's either production or its trees and there's nothing in between.
> *– A civil society representative and farmer (from interviews).*

There are ongoing programs that demonstrate the envisioned educational design of soil (health) education, such as Cranfield University's new Apprenticeship/MSc in Soil Science and the Soil (health) Nutrient Health scheme in Northern Ireland. These initiatives offer valuable insights into practical and collaborative approaches to soil (health) education.

General public

Vision: To enhance soil (health) awareness in society by emphasizing the importance of healthy soils for ecological and human systems without narrowly focusing on specific EU mission goals, SDGs, or human development aspects.
Needs: To enhance accessibility, engagement, and inclusivity of soil (health) educational resources, adopt a simple language and create educational materials that integrate foundational knowledge and practical skills within broader ecological contexts.
Opportunities: There is an opportunity to expand upon existing public interest in soil (health) and resources focused on soil (health), as well as citizen science projects.

State and wishes of soil (health) education

Purpose: Educational opportunities available to the general public on soil (health) take an expansive approach and are offered through various media, including introductory videos on the importance of soil (health) (e.g., British Society of Soil Science, 2020, December 4; The Royal Society, 2020, May 5), detailed explanations of soil science concepts such as soil structure (British Society of Soil Science, 2021b), and the role of healthy soils in sustainable food production (Global Food Security, 2013). Developed mainly by the British Society of Soil Science, these resources align with many Mission Soil objectives, including *conserving soil organic carbon stocks, reducing soil pollution, preventing erosion, enhancing soil biodiversity,* and *improving soil literacy.* There is less

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focus on goals concerning issues that are considered less relevant to the UK, such as *reducing desertification* and *reducing the EU global footprint on soils*.

These educational resources also embed several SDGs, and certain resources like the British Society of Soil Science's 'Soil and the SDGs' video series explicitly connect soil (health) with SDGs such as *life on land*, *zero hunger*, *sustainable cities and communities*, and *clean water and sanitation* (British Society of Soil Science, 2022b). Interestingly, SDG *climate action* is weakly embedded in these resources, while goals like *no poverty* and *reduced inequalities* appear to be absent. Also, there is limited information on the degree to which these resources are actually used by the public.

> I think it's actually a very exciting time in soil science at the moment. Very exciting. Largely as a consequence of the research done to understand climate change and the role soils play in it. So yeah, I think it's a very exciting time to try and get some of these messages out there.
> *–A lecturer and soil scientist (from interviews).*

In terms of human development, *knowing, doing,* and *being* are in general considered weakly embedded due to there being limited soil (health)-specific educational resources and/or activities developed for the general public, as well as there being little evidence to suggest that those educational opportunities are widely engaged with. However, the educational resources that do exist for the general public tend to incorporate all the three purposes of *knowing, doing*, and *being*. For instance, the Open Air Laboratories (OPAL) citizen science Soil and Earthworm Survey (Head et al., 2016) highlighted the critical role of soil (health), emphasizing its importance for plant survival, crop production, water storage, and filtration, and as a habitat for diverse wildlife including earthworms. While the survey effectively engaged participants of all ages in developing soil knowledge and basic survey skills, it is no longer active.

The wish is to raise the level of soil (health) education and its importance for ecological and human systems in broad sense, without necessarily placing special emphasis on any specific aspect of EU mission goals, SDGs, or human development.

Collaboration: Soil (health) related education for the general public is predominantly offered through *narrow* collaborations which commonly include resources developed by a single organisation. These include online courses (e.g. Lancaster University, n.d.), posters (e.g. British Society of Soil Science, 2023a,e), reports (e.g. Global Food Security, 2013), videos (e.g. The Royal Society, 2018, June 29), and podcasts (e.g. Royal Geographical Society, 2022, December 8). Occasionally, collaborations take a *narrow-broad* approach, where multiple stakeholders co-develop and co-deliver soil (health) educational resources or projects. For instance, the OPAL Soil and Earthworm Survey was co-produced by Imperial College London, British Geological Survey, Natural History Museum, Field Studies Council, Environment Agency, and University of Central Lancashire (Head et al., 2016). This citizen science initiative exemplified collaborative learning in action. The wish is to broaden engagement across diverse segments of society and increase public participation in soil (health) education.

Space: Learning space for soil (health) education for general public is predominantly *indoors* from engagement with written, visual, and audio materials. For instance, they may

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practice soil classification techniques to identify soil types and assess soil quality (e.g., British Society of Soil Science, 2023e). These resources often encourage learners to apply their knowledge *outdoors*, although the extent to which *outdoor* education actually takes place depends on individual motivations. The wish appears to strengthen the *outdoor* components.

Process: Soil (health) awareness offers for general public are predominately facilitated through *instructive* processes with components of *emancipatory* processes. Generally, the educational resources provide instructions, for instance in the form of 'top tips' for improving soil (health) (e.g., UK Soils, 2023) or contextualizing soil degradation issues for a UK audience (e.g., Kennedy, 2022). The learning process remains open, informal, and self-directed. Individuals decide how to utilize the knowledge acquired. The wish is to strengthen the *emancipatory* process.

Activities: In soil (health) awareness offers for general public, *knowing-based* activities (e.g., focussing on providing facts about soil processes or recommended garden soil management techniques) predominate with weaker components of *doing-* and *being-based* activities. An example that integrates *knowing-* and *doing-based* activities, with potential *being-based* outcomes, is the Sensing Soil project coordinated by Cranfield University and Goldsmiths University of London (Cranfield University, n.d.). This initiative aimed to increase public engagement with climate change through participatory artistic activities, climate science, and gardening practices in an outdoor garden environment. The garden evolved into a space fostering scientific learning and providing a platform for discussions and insights into art, climate science, and ecology. The wish is to adopt activities that combine all three *knowing-*, *doing-*, and *being-based* activities.

Paradigm: Soil (health) awareness offers for general public adopt both *mechanistic* and *ecological* paradigms. For example, an *ecological paradigm* is exemplified in an educational article emphasizing that transitioning to soil (health) practices involves applying comprehensive soil (health) principles rather than rigidly adhering to specific methods. The article advocates for heightened awareness across all aspects of agricultural management, promoting continuous improvement through critical evaluation, and adaptation of practices to enhance soil (health) (Corfield, 2018: 16). Predominance of *ecological* paradigm is wished for soil (health) education for the general public.

Gaps, challenges & opportunities

While there are resources for soil (health) education available to the general public, there is little evidence on the extent of engagement with these resources. In addition, the low level of public awareness and education on soil (health) further makes it difficult to establish meaningful connections between soil (health) educational initiatives and global sustainability goals. To address this, soil (health) education needs to be relevant, engaging, and accessible to foster broader public interest and understanding. This requires creating and promoting educational resources that focus on both foundational knowledge and practical skills within the context of broader ecological and human systems. Communicating

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the importance of soil (health) to the general public remains a fundamental challenge. To address this, there is a need to present soil (health) educational resources in simpler, jargon-free, everyday language.

There is a wish to transition towards soil (health) education that predominantly takes place *outdoors* and is facilitated through *emancipatory* processes combining *knowing-, doing-,* and *being-based* activities. Realizing this wish requires financial support and adequate resources for educational initiatives. For instance, collaborations in soil (health) education often depend heavily on external funding due to their non-formal nature, making sustainable funding a recurring challenge. Additionally, the lack of suitable outdoor learning spaces hinders the ability to offer outdoor education, especially in urban areas. Fortunately, a portion of the population already shows interest in soil (health), presenting an opportunity for targeted education and citizen science initiatives focused on soil (health).

> Scientific community has a real job to do to, you know, stop looking for the third decimal on soils. Just get really clear about the basics and make them available to everybody. And then I think that upon that foundation, you start building engagement and you start building a sense of direction [for soil (health) education]. – *An NGO leader (from interviews).*

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B. Analysis of questionnaire data

In the first study, the questionnaire gathered an overarching insight on the research questions (GRQs 1 and 2), exploring both the current state and the wishes for soil (heath) education in 15 LOESS partner countries. For each GRQ, and for each educational dimension of the conceptual framework presented in section 3.1, country partners were asked to rank various descriptors, indicating the level of dominance for the current state or preference for the wishes. Depending on the GRQ and the dimension explored, the number of ranking options (descriptors) varied between 2 (Space, Process, Paradigm) and 8 (Purpose in terms of SDGs). In this context, a lower rank corresponded to a higher preference, i.e. rank of 1 for most preferred option.

To analyse the data, a weighted mean score estimation was applied. Weights were assigned to each rank based on its relative position to the total number of options. For instance, for a question with 3 ranking options, the option ranked 1 was assigned a weight of 2, option ranked 2-a weight of 1, and the least preferred option (ranked 3)-a weight of 0. The weights were adjusted depending on the total number of *descriptors* for each dimension and related GRQ. The percentage weighted score for the *descriptor 'i'* was determined as:

$$\text{Percent Weighted Score}_i = \left(\frac{\sum_{i=0}^{n-1} f_i \,.\, w_i}{\sum \sum_{i=0}^{n-1} f_i \,.\, w_i}\right) \text{x } 100$$

Where,

'f'_i is the frequency of the *descriptor 'i';*

'w_i' is the weight assigned to descriptor 'i', based on its rank;

'n' is the total number of descriptors.

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