

**TOUCHING THE SOIL:
URBAN INTERVENTIONS FOR
SUSTAINABLE TRANSITION.
A REAL CASE ANALYSIS OF CITIZEN SOIL
SCIENCE IN MEIDLING, VIENNA.**

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ABSTRACT

This thesis explores the transformative potential of Citizen Science in Soil (CSS) for fostering a liveable sustainable urban future. Rooted in care and environmental ethics and aiming to contribute to Socio-ecological Transformation (SET), the study employs a situational grounded analysis approach. Deep literature research helps to identify important factors and provides fundamental knowledge about the subject of investigation. Through a real-world case study of a public soil testing project conducted in Meidling, Vienna, utilizing the Open Soil Atlas (OSA) methods, the research analyses the societal impact of CSS. The final situational map visualises the outcomes of the study in context to the SET. Therein the most important factors of the case study and its interrelations are represented. The study finds that CSS has a direct impact on citizens in the four categories of excitement and curiosity, education, engagement, empowerment. With this it serves as an adaptable experimental intervention, that can serve as a tool to foster exchange, raise awareness and catalyse positive change.

Keywords:

Citizen Soil Science, Socio-ecological Transition, Green Urbanism, Citizen Engagement, Resilience.

LIST OF CONTENTS

CHAPTER I – RESEARCH CONTEXT

1	Introduction	5
2	Literary landscape	12
3	Theoretical Background	16
3.1	The shift to a socio-ecological transition	16
3.2	Ethical Premises	23
4	Study design and structural underpinnings.	27
4.1	Contextualization of the Researcher	27
4.2	Implied Methodology: Situational Grounded Analysis	27
4.3	Ethical Implications	30

CHAPTER II – LITERATURE RESEARCH

5	The importance of soils	32
6	The importance of Citizen Engagement	38
7	The need of green urban infrastructure	43
8	Current political soil landscape in the EU and Vienna, Austria.	48

CHAPTER III – CASE STUDY EXECUTION

9	Key stakeholder groups	51
9.1	Place of conduct: Meidling	51
9.2	Facilitating association: Open Soil Atlas	52

10	Case study methods: OSA meets Meidling	56
10.1	Method 1 – Workshop design and implementation	56
10.1.1	Workshop – Population and sampling.....	56
10.1.2	Workshop – Analysis	57
10.1.3	Workshop – Design and outcomes	58
10.2	Method 2 – Survey design and implementation	66
10.2.1	Survey – Population and sampling	67
10.2.2	Survey – Design and outcomes	67
10.3	Review by Mei Meidling – Blog entry	69
11	Situational Analysis	70
11.1	Situational Analysis - Design and outcomes	70
11.2	Situational Map	74
CHAPTER IV – RESEARCH EXAMINATION		
12	Citizen Soil Science for the socio-ecological transition	76
13	Conclusions	82
INDEX		
A)	Facilitation guideline – Opening round	I
B)	Survey questions	II
C)	Screenshot of legend and environmental map of Vienna depicting soil values.	III

FIGURES

<i>Number</i>	<i>Page</i>
<i>Figure 1: Sustainability transition with implemented SDGs as endpoint.....</i>	<i>17</i>
Figure 2: The general transformation to a sustainable world through various transitional sustainable development pathways, which are moving within the framework of the SDGs.	18
Figure 3: Terrestrial biodiversity loss.....	21
Figure 4: Proportional division of societal actors for urban climate change experiments. (Harriet Bulkeley et al., 2015, p. 34).....	22
Figure 5: Authors procedure of the thesis.....	30
Figure 6: Soil Species Dominance.....	34
Figure 7: Schematic graphic showing how soil functions for human well-being are linked to ecosystem services through important soil qualities.	35
Figure 8: Green urbanism with its tree main pillars and their interaction.	44
Figure 9: The four fields and 15 principles of green urbanism.	45
Figure 10: Reasons of the urban heat island effect, comparing rural to urban area.	46
Figure 11: Necessary tools for the testing.....	54
Figure 12: Photo of the generated Berlin map by the end of the OSA examination time in 2021.	54
Figure 13: First parts of the soil testing manual.....	55
Figure 14: Introductory round at the first location.....	58
Figure 15: Position of the four soil sampling subgroups (A-C) in the park.....	61
Figure 16: Test location A.....	62
Figure 17: Test location B	62
Figure 18: Test location C	62

Figure 19: Test location D.....	62
Figure 20: Presentation about the <i>Klima-Grätzl</i> concept by participant 13.....	66
Figure 21: Reaction of soils with vinegar.....	66
Figure 22: Situational map of Citizen Soil Science in relation to the Socio-ecological Transition.	75

TABLES

<i>Number</i>	<i>Page</i>
Table 1: Participants demographics, including special characteristics.....	57

ABBREVIATIONS

CSS: Citizen Soil Science

OSA: Open Soil Atlas

SDGs: Sustainable Development Goals

SET: Socio-ecological transition

CHAPTER I – RESEARCH CONTEXT

In the following chapter the overall context of the research is laid out by an introduction, the literary landscape of the topic, a theoretical background, and the methodology of the overall study.

1 Introduction

The Anthropocene, the current geological age of human-dominated environment, has changed the Earth (Gamper, 2024). This process, which began with occasional periods of resource development and regional growth, accelerated and now threatens the entire planet through the production of greenhouse gases, climate change and the loss of biodiversity and cultural diversity (Moran, 2011, p. 11). In numbers, 60% of Earth's ecosystem has been degraded over the past 60 years. The exponential population growth along with urbanization and industrialization have changed the way how humanity interacts with the environment (*Directive on Soil Monitoring and Resilience*, 2023; The World Counts, n.d.). Caused by humans' exploration of and detachment from nature, the Earth suffers challenges that must be faced and tackled through all possible interventions.

For the UN 2030 Agenda for Sustainable Development 17 Sustainable Development Goals (SDGs) were introduced. The aim was to limit global warming to 1.5 degrees Celsius by 2030 (United Nations, 2021) and to achieve climate neutrality in the EU by 2025. Not enough has been done yet to reach these goals and the list of environmental challenges is long. Given the estimate that by 2050 70% of the global population could be living in urban areas (United Nations, 2019), cities are one of the main factors that must be dealt with when tackling the climate crisis. "Liveable cities offer high-quality services and increased 'naturbanity', a close connection between people and nature, to enhance human health and well-being, protect biodiversity, and strengthen climate resilience." (United Nations, 2019, p. 84). In that sense, "naturbnity" sees

cities like ecosystems where nature and humans coexist peacefully and exchange resources within a sustainable framework.

Considering that city growth implies a high population density and contested spaces, cities need special attention. Through paved areas and a lack of shade, heat islands are affecting human health. Besides, sealed surfaces promote disasters such as flooding, and a lack of biodiversity leads to the continuous extinction of flora and fauna, to name but a few of the effects of climate change in the city. This requires not only political ideals but also a high degree of joint social action with a comprehensive understanding of and a common will to change, as SDG 13 also emphasizes. In the process of a sustainable transformation it needs more citizens in action because greening movements can advocate for environmental justice, promote community economic development, address health disparities and advance equity in urban infrastructure (Birch & Wachter, 2008). In the Global Sustainable Development Report from 2019, liveable cities are closely seen in relation to social and environmentally friendly approaches. Focusing on sustainable cities and communities, SDG 11 addresses this topic, addressing the city as ecosystem, and the community as a social space in equal measure. A *socio-ecological transition* (SET) is needed to find effective solutions and create liveable spaces.

Historically, city planning mostly excluded nature from the so called 'civilized' human spaces or put it in cramped city parks in Western Societies (Breuste, 2019) and still, most people don't give attention to their natural environment. The problem of heating islands and flooding is becoming increasingly evident. Especially in densely populated city, there is a need for a better understanding and increasing public recognition of the often-unrecognized matter below our feet, the soils. The dichotomy of human and natural space needs to be resolved to creatively respond to current problems and adapt to climate change. Since the industrialization triggered an ongoing

extractivist human behaviour, the interest in, and the loss of knowledge about soils is commonly ongoing (Gamper, 2024).

The advantages that a healthy soil-habitat can offer are enormous. In the context of nature-based solutions soil can grow vegetation that provides shade and has a cooling effect. In loose, perforated soils of flower beds or tree grids, water can find its way, and can then be absorbed by a healthy ecosystem (Albert et al., 2019; Breuste, 2019; Davies et al., 2021; Frantzeskaki et al., 2020; Wendling et al., 2018).

Based on the EU Green Deal an EU Soil Strategy has been introduced in 2021 (*EU Missions - Soil Deal for Europe*, n.d.). Even the EU Biodiversity Strategy and the EU Farm to Fork Strategy pursue objectives that it could help to realise (Mason et al., 2024, p. 2). Additionally, the EU proposed a new soil monitoring law on July 5, 2023, with the goal of safeguarding soils, restoring them, and ensuring their sustainable use (*Soil Health. European Commission*, 2024).

Furthermore, on 20 February of 2024, the EU Council and Parliament recently reached a provisional political agreement on reducing carbon emissions in the EU, including soils, based on a certification framework. However, it has yet to be formally adopted by Member States in the Council and the Environment Committee of the EU Parliament before it can be published in the Official Journal of the EU and enter into force (Council of the European Union, 2024). Nevertheless, this current discourse shows that soils can be identified as a hot topic, which is intricately linked to SDG 15, life on earth.

The Feld Food Forest association, of which the author is a member, was founded in Berlin with the aim of becoming a co-creator of change, strengthening the connection between people and nature and promoting a culture of cooperation, empowerment and knowledge sharing (*Feld Food Forest – Growing a Healthy Community in Berlin*, n.d.). From within this circle, with the goal to generate a high-resolution soil map, the Open Soil Atlas (OSA) was created as a

participatory "open-source co-learning centre" for citizens. In addition, awareness of soil quality, fertility, one's own environment, and the connection between healthy soil and a healthy community was aimed. They were funded by Action, as part of the EU Horizon fund, which is the monetary support of the EU Green Deal (Busnardo et al., 2022).

Meanwhile, in Meidling, Vienna's 12th district, an exploratory project for an architectural climate adaptation measure in environmental and social terms was carried out but has not yet been implemented. Still, with the aim of improving the quality of their living environment, a closer participatory exchange was sought between residents and politicians, as well as public administration, businesspeople, and experts (Forschungsförderungsgesellschaft, n.d.; Grünstattgrau, n.d.; Mei Meidling, n.d.; *Mei Meidling - über uns*, n.d.).

During this time, a few proactive neighbours got involved and founded the *Mei Meidling* association. To achieve the goal of a comprehensive, future-proof shared community living space, they want to keep the dialogue alive and engage the neighbourhood (Mei Meidling, n.d.-b). Therefore, the Meidling neighbourhood is an interesting setting for the application of OSAs methods and their approach to the matter of soil.

These two examples show the willingness of people to trigger change and innovation through citizens' engagement. Natural solutions must gain greater recognition as an instrument of climate adaptation, but holistic approaches are needed that are both based on scientific findings and inform and involve the public. Establishing a clear link between community and urban soil systems challenges, not only influences the research objectives for urban soils, but also challenges urban scientists to expand the concept of cities as interconnected social and ecological systems (Beatley, 2000; Harriet Bulkeley et al., 2015; Iokiñe Rodríguez et al., 2023; Schwarz et al., 2022).

There are people and green movements demanding a change in the city but how does people's engagement with and in their environment change when touching and understanding soils through collective testing? What effect does it have on their reconnection with nature and

within each other? To what extent does this achieve residents' awareness for soil issues, such as unsealing, planting opportunities, heat islands, etc.? How can this support the overarching goal of socio-ecologic change? By conducting a public soil testing in Meidling, Vienna, with the methodology of OSA, the author wants to explore these specific questions and people's social and ecological experiences in greater depth. This research therefore centres around the pending research question:

How does citizens' contact with urban soil strengthen their connection with nature and with one another, and their general engagement with the environment?

Soil testing through *Citizen Soil Science* (CSS) is an experimental intervention that is worth looking at to improve citizens' realities and create liveable cities. Even when the field of data science and urban planning will be touched, this work will not cover soil data analysis, nor the reconceptualization of urban spaces, which would be more subsequent to this analysis.

Since local challenges need local answers, it is important for local policies to provide a framework for effective *transdisciplinary* innovation in combination with other actors, including citizen engagement (Iokiñe Rodríguez et al., 2023; Lawrence et al., 2022; United Nations, 1992). Transdisciplinarity, in short, denotes a way of conducting science that accounts for myriad ways of knowing and inscribes perspectives and knowledges otherwise not present in science, through a variety of stakeholders in an iterative practice of collective knowledge creation or integration (see Pohl et al., 2021; Scholz & Steiner, 2015b, 2015a). Here, maintaining experimental works is important to understand which elements of novelties are integrated and can be reconfigured. Such projects help to understand the effects and implications and raise policy questions.

Working with the local population can lead to far-reaching benefits, such as a wholesome neighbourhood that identifies with its surroundings. As a result, it is possible for these places to become highly valued and long-term maintenance is more likely to be guaranteed. Without

heating islands people are healthier and without flooding, houses and open spaces are protected from damage, which in turn benefits local politics (Artmann et al., 2019; Beatley, 2000; Harriet Bulkeley et al., 2015). With the awareness that community-based activities for ecological adaptation are supported by municipal governments, locally organized environmental groups can be seen as a key factor of response and have an impact on municipalities.

As municipalities are part of a network of governments, everything is interconnected and stories about climate change move from the local to the global level and vice versa (Harriet Bulkeley et al., 2015, pp. 23, 24). Emerging countries in particular are facing environmental degradation, due to careless environmental behaviour and a lack of environmentally friendly attitudes (Nahar et al., 2023, p. 7504). Thus, even though this thesis, with the case study of OSA in Meidling, refers to an extremely specific context, the findings and lessons-learned can provide valuable insights into the motives that drive people to the topic of soil, and in what sense it might connect them. It becomes apparent that developing a theory on soil as a medium of engagement could help to find solutions and subsequently, develop an adaptable policy where soil could act as a local natural climate adaptation measure in the built environment.

Aiming for an understanding of citizens' connection with their environment through CSS, the study will overall foster and support the SET. Rooted in care and ecological ethics, the empirical study will be evaluated through situational grounded analysis. The thesis is organized in three big main sections: Chapter 1 – research context, chapter 2 – literature research, chapter 3 - case study execution, and chapter 4 – research examination.

In chapter 1 the study, and the wider context in which the study is to be placed, are contextualised. Following the introduction, an overview of the literary landscape of the specific CSS study field is provided. Then, it follows a thematic overview and classification in the respective research context SET, and its ethical premises. To introduce the research, the

methodology is outlined, including details of the author's role, details of the used methods, and ethical implications of the fieldwork.

In chapter 2 the outcomes of the conducted literature research “the importance of soils”, “the importance of Citizen Engagement”, and “the need of green urban infrastructure” are analysed as important factors of CSS in the city. This is followed by the “current political landscape in the EU and Vienna, Austria” to frame the following CSS case study.

In chapter 3, first, the methods of the CSS case study, together with their outcomes will be provided. This includes the workshop and the survey, as well as a blog entry that was maintained following the CSS. As a result of the overall situational analysis, the generated CSS situational map is closing this chapter and forms the basis for the discussion in the 4th chapter.

In chapter 4 the outcomes of the case study are examined. First, the outcomes of the case study together with the CSS situational map are discussed in context within the SET. Then it will follow a conclusion part, where final outcomes are summed up and important takeaways are highlighted.

The author is aware that she is only referring to urban areas with this specific example. Furthermore, with the district of Meidling, she is working in a context in which environmental awareness may already exist. Nevertheless, the topic of soils is probably not in focus to this extent. New ideas are relevant in climate change governance for cities and model cities are used as examples for baselines globally (Harriet Bulkeley et al., 2015, p. 29). Thus, from analysing this precise case, lessons can be learned, and conclusions can be drawn to understand its effects.

2 Literary landscape

In this part a review of some of the most important literature, and other sources, that were considered for conducting this thesis will follow. Within, restrictive fields are described, and subjects in context of the study are introduced.

For this study numerous topical sources were reviewed and evaluated according to their quality and relevance, to then be selected for the final work. This thesis is mainly built on the OSA project, in which the author was involved. Its implementation had been supported by ACTION, a tree year program to transform participatory science against pollution, funded by the European initiative 'Horizon'. Information on OSA can be found in the final paper of the project by Busnardo et al. (2022), the projects web page *Open Soil Atlas (in Notion)* as well as the official web page of the umbrella association Feld Food Forest. Additional information is also provided on the web page of the *ACTION Project*, as well as their final paper by Gefion Thuermer et al. (2022). Yet, to this day, a direct academic debate on the impact of soil testing on the individual and the unit in the context of SET is still missing, which will be addressed with this thesis.

In general, no credible academic papers known to the author were found in the literature that address urban soil testing through CSS as an experimental intervention. Still, some experimental projects can be found when researching the subject, where CSS was used to gather soil data and foster environmental education. One of them is Schneider et al. (2020), who introduce the Tea Bag Index to measure the decomposition rate and litter stabilisation with tea bags. The other is the global *Soil Your Undies* challenge in which cotton underwear is used to measure soil health in different locations, most recently in Switzerland in April 2024 with the "Beweisstück Unterhose". Both projects served as an inspiration to this thesis, which, however, has a decidedly more academic focus.

In a recent study from 2024, Mason et al. conducted an exemplary sighting of current research on the topic of citizen science projects that engage with various academic foci. The paper reveals that a total of 191 publications contain relevant projects dealing with crossed issues of “soil” and “*Citizen Science*”, two-thirds of which have been published in the past 2 years (p. 2). Further, 1186 papers tackle the intersection of “biodiversity” and “*Citizen Science*”. This means two things: Firstly, the above topics are of great interest and gaining traction in academic endeavours, as both scientists and expert practitioners become aware of their lasting social and ecological importance. Secondly, the specific focus on “soil” is comparatively underrepresented, which contributed to the choice of topic for this thesis.

Mason et al. (2024) are evaluating some experiments academically, yet their investigation remains primarily focused on agriculture. One interpretation of this fact might be that there is a certain economic benefit here and that relevant sponsors from the agro-industry are attracted to fund such research. However, this still highlights the potential of CSS as an underutilized resource for European soil health research and its value in upscaling soil data gathering. The central principle is therefore to deepen interest in soil issues, citizen science and a more holistic approach to nature across all disciplines and stakeholders.

Due to the topicality of the subject and the aim for a shift to more sustainability, some recent articles and information can be found on the United Nations website. Exemplary for this is the newly introduced carbon removal framework, including soils, by the Council of the European Union (2024), the COP26-outcomes by the United Nations (2021), and several fundings provided by the EU, such as the Horizon fund. Voulvoulis et al. (2022) delve into geopolitical structures when examining systematic sustainability transformation, including the SDGs. With this they provide a framework for the overall landscape of why interventions must happen and what influence they might have.

Numerous academic research investigates the notion of socio-ecological change. Emilio Moran (2011) and Olivier Lefebvre (2022) both examine the paired evolution of social and ecological systems. While Moran emphasizes the exponential expansion of this process and its worldwide influence, Lefebvre concentrates on the shift from a societal vision of nature that is artificial to one that is sustainable, so to say less characterized by the industrial past. Therein he also touches on power imbalances and calls for communal action.

According to Harriet Bulkeley et al. (2015) transdisciplinary responses, new forms of collaboration, and of governance are needed. This idea is backed by Stephen Jackson (2021), who emphasizes the necessity for an innovative transformation in society's attitudes and more experimental practices for alternative future states. Additionally, he states that applying effective, adaptive techniques to understand and control such shifts is an important issue for the scientific, managerial, and policy sectors. On this end, Iokiñe Rodríguez et al. (2023) provide a more critical perspective not only on how to achieve socially just transformations but also point out the hurdles for citizens movements. These studies highlight the importance of system change for the transition to a more sustainable and environmentally friendly society. Moran and Iokiñe Rodríguez et al. specifically underline the importance of community and the importance of power to local decisionmakers.

More practically examples are Ferreira and Carvalho, (2021), Nahar et al. (2023) and Schwarz et al., (2022). Whilst Ferreira and Carvalho investigate motives for transition engagement in a grassroots movement in Portugal, Nahar et al. and Schwarz et al. focus more on perceptions, awareness and knowledge about urban environments. Whereby Nahar et al. are more concerned with sustainable urban environmental management in Dhaka, Bangladesh, they find a low awareness between society and call for more environmental education. While Schwarz et al. work on researching a framework for urban soil research policy, public education and community engagement in Los Angeles, CA, United States and conclude that "people in

cities are the advocates, educators, and caretakers that soil systems need”. These applied studies were used in this thesis to move from an abstract level to more direct examples.

Mark Ryan (2016) also creates a so-called *Precautionary Ecosystem Health Principle*. Here he combines environmental health principle and the often-accruing precautionary pressure to act, when urgent problems arise, and therewith suggests guidelines for effective change.

Reflecting on the history of environmental activism and environmental ethics helps this study to understand the reasons for the context. Palmer et al. (2014) expands this study, by providing insights on the development of environmental ethics in the 1970s from a Western perspective. It is examining statements about what is valuable from both an anthropocentric and nonanthropocentric perspective. In addition, Samuel Bassey’s (2018) perspective provides a comprehensive inside into the research on ethical norms relevant to the human-nature nexus and governance in the 21st century.

Birch & Wachter (2008) investigate greener cities for urban sustainability in their book, which is also forward-looking for the 21st century. In his paper, Timothy Beatley (2000) analyses European cities for green urbanism. In this context, the term biodiversity-climate-society nexus is subject of investigation by Lampinen et al. (2023) which explore the social and perceptual reasons for how participatory methods support a just and lasting urban and green infrastructure planning.

Many, mostly new contemporary sources are informative and inspiring for the beauty of subsurface wealth succinctly David Wolfe’s (2002) book: “Tales from the underground: a natural history of subterranean life ”and the web page *A Chaos of Delight* (2021). Besides, a vast number of exhibitions are tackling the topic, for example *Soiling the Anthropocene* (2024) which took place in Belvedere 21 in Vienna. Two texts by Verena Gamper (2024) and Nora Vaage (2024) are taken from the exhibition and serve as an approach to the topic of soil. Further scientific insights on soils and their functions can be drawn from Adhikari & Hartemink (2016).

The *Mei Meidling* and *Grünstattgrau* associations were consulted in particular for information about the study district of the case study.

For the City of Vienna, the website of the municipal authority (Stadt Wien) was analysed for the following areas: Soil types in the city map, Parks and gardens in Vienna, Environment & climate protection. For further information on the current status at EU level, the *EU Mission* form 2024 was used and will be laid out in the current status chapter.

For the methodological framework, the author combined the leading methodological framework for this thesis of Adele Clarke's situational analysis (2005) and the underlying grounded theory after (Strauss, 1987), partly with the observation methodology of "interaction and communication in groups" by Christine Rottenbacher (2005).

3 Theoretical Background

In order to understand social interventions in the name of environmental protection, it is necessary to establish basic foundations. First, the all-encompassing frame of SET is presented, followed by some ethical premises, which will help to conceptualize this thesis.

3.1 The shift to a socio-ecological transition

The concept of SET is often used as an umbrella term to describe a range of approaches and ideas. The use and definition of terminology is very inconsistent in the various areas in which it operates or which it defines. However, in etymology the word ecology translates to "home" derived from the Greek word *oikos* (Vaage, 2024, p. 85), which already gives a hint to its relevance in relation with sustainability on planet earth.

Overall, the focus lays on achieving a sustainable future in which human societies and ecological systems can coexist sustainably. Thus, instead of SET one can find sources that address the same topic but in the framework of climate-society-nexus (Lampinen et al., 2023). The various descriptions and concepts that refer to the same concept of SET come with several

different terms and understandings. In literature, the term *transformation* is often used instead of or in conjunction with *transition* (Iokiñe Rodríguez et al., 2023; Jackson, 2021; Moran, 2011; Voulvoulis et al., 2022). Yet, here the term transition is used to describe changes in subsystems and can be understood as multiple parts of an overall transformation of a large-scale change process (Hölscher et al., 2018).

Transition in its only understanding describes the path of a specific theme whereby it follows a storytelling narrative. Often caused by a multi-crisis, its transformative structure includes a beginning, a core and an end, which usually proposes the solution (Ferreira & Carvalho, 2021, p. 46). Ferreira and Carvalho (2021) describe transition narratives “as the ways in which participants envision the kinds of worlds they would like to bring into existence, expressing their views on the economy, technologies, interpersonal relationships, and the good life” (p. 43). With this, many transition narratives work partly on the thrive for a global utopia.



Figure 1: Sustainability transition with implemented SDGs as endpoint (Voulvoulis et al., 2022, p. 4).

As exemplified in *Figure 1*, the response to the climate multi-crises is to transform unsustainable states (A) into sustainable, the desired states (D) and this with reach the distinct SDGs. In it, the process is referred to as the sustainability transition, with the SDGs providing a normative framework and the desired goal (Voulvoulis et al., 2022, p. 3). As shown in *Figure 2*, transformation is reached, when this multiple transition paths, in form of the achievement of the SDGs, come together. Facing the climate multi-crisis current societies are confronted with various

problems that need to be tackled. At the end of SET would ultimately be sustainable societies that would tackle all problems accordingly. With the CSS not only one SDG but, as mentioned before, SDG 11, 13 and 15 are addressed.

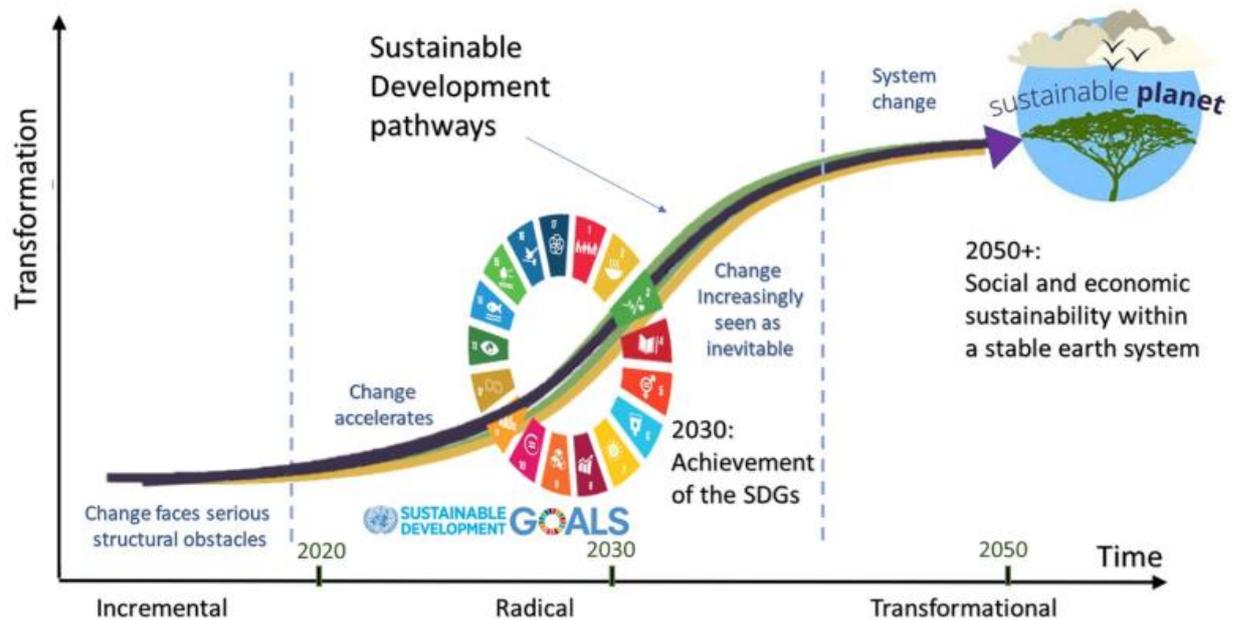


Figure 2: The general transformation to a sustainable world through various transitional sustainable development pathways, which are moving within the framework of the SDGs (Voulvoulis et al., 2022, p. 2).

Socio-ecological systems have been under severe pressure since the middle of the 20th century. Reasons for that are the growing population, associated continuous appropriation and extraction of natural resources from the ground and space, as well as the increasing complexity of climate change. Even when the shift to climate resilience is a global trend (Jackson, 2021, p. 1), Moran emphasizes that the imbalance of ecosystems is exponential and that the transformation of social and ecological systems is of “planetary significance” (p.1). Thus, the environmental problem, as a global problem, must be met on a global level.

However, SET becomes a long-lasting operation precisely when such a complex multilayered process is at stake. Conflicts over the direction and pace of change, and when it

involves interrelated changes to corporate models, social practices, laws, and cultural norms are time consuming (Voulvoulis et al., 2022, p. 4).

A linear single-layered issue may be answered in a usual way. However, as already mentioned, the multilayered SET requires a structural understanding for a paradigm shift. Therefore, so-called "systems thinking", in which the complexity and interrelationships of the individual components of a system are understood in relation to the whole (Anderson & Johnson, 1997), the individual influencing factors can be addressed appropriately, resulting in a smoother transition process (Voulvoulis et al., 2022, p. 1). In the example for a full SET "system thinking" provides a systemic framework that emphasizes the interconnections of the SDGs and integrates feedback loops within socio-ecological systems.

Systems thinking builds on an interactive exchange between science and the public, as well as exchange at international level to learn communally (Voulvoulis et al., 2022, p. 3). Currently political interventions do not tackle the faced issues at the required velocity and even with current sustainability science and political interventions, the global population is still on a largely unsustainable development path (United Nations, 2019) and therefore must be addressed independently in order achieve the desired goal. If sustainability science could provide calculated information and effectively clarify the causes of crises, policymakers should be sufficiently informed and act accordingly (Voulvoulis et al., 2022, p. 2). But even when politics or science provide guidelines that help humanity to act, it still needs citizens to take over responsibility and change.

At that point, SET includes the aim to tackle the existing lack of people's awareness "about the cosmos beneath our feet" (Gamper, 2024, p. 49). It actuality calls for a change that centrally addresses people's mindset with care (Voulvoulis et al., 2022, p. 3). Therefore, it is important to shift the common understanding of nature in society. The general definition should move from an "artificial nature", which corresponds to the industrial age, to a "sustainable nature"

(Olivier Lefebvre, 2022, p. 218). A “sustainable nature” would provide measures for interrelated variables of nature with comprehensive scientific knowledge (p. 216), of which soil data can be one. This would not only make human environmental impact visible, but with the involvement of society, would even create a common understanding of the interconnection of environmental systems and could trigger sustainable innovation.

To change structural dominance, collective efforts are needed (Voulvoulis et al., 2022, p. 3). Transdisciplinary approaches and versatile strategies, such as “adaptive learning, creative approaches, and close partnerships between communities of research and practice” (Jackson, 2021, p. 1086), can support this process to effectively propose “alternative future states” (p. 1086). This requires measures from the vertical to the horizontal direction that involves a variety of stakeholders (Bulkeley et al., 2015, p. 3) and also applies to the way in which different measures are carried out and implemented.

Moreover, when considering the societal level, it is important to actively involve the target groups affected since local communities are in relevant contact with issues and can work as direct actors for the SET. They therefore need a certain degree of ownership in order to effectively address the climate emergency and the threat of environmental deterioration (Ferreira & Carvalho, 2021, p. 42). This can even be done independently from political decision-making and be achieved through bottom-up and grassroots approaches (Ferreira & Carvalho, 2021, p. 47). Through such approaches, people are mobilized and participate in global agendas. They can utilize their situated knowledges and their unique ways of knowing that is otherwise left out (Haraway, 2016).

Although sustainability science is addressing complex challenges, it still needs improvement of society’s ability to translate behavioural science findings into practical changes for improving sustainability (Voulvoulis et al., 2022, p. 4). In consideration of holistic actions for

more ecology in cities, Olivier Lefebvre (2022) proclaims the five Rs of: “revolution, regeneration, renovation, reform, and regulation” (p. 212).

When addressing ecological issues, one of the key aspects for a functioning ecosystem, such as soils, is minimizing the loss of biodiversity (Jackson, 2021, p. 1086). Terrestrial ecosystems are most affected by anthropogenic land use and direct exploitation, followed by the two factors climate change and pollution (*Figure 3*). They need protection to keep functioning. Further, it is not rational to demand spaces that are free of human impact. This would not do justice to the fact that the human species already has left a negative impact on all living creatures and habitats of this planet. Conclusions should therefore not only address problems that have already arisen, but people should instead restore natural habitats and support the regrowth of biodiversity (Ryan, 2016, p. 228).

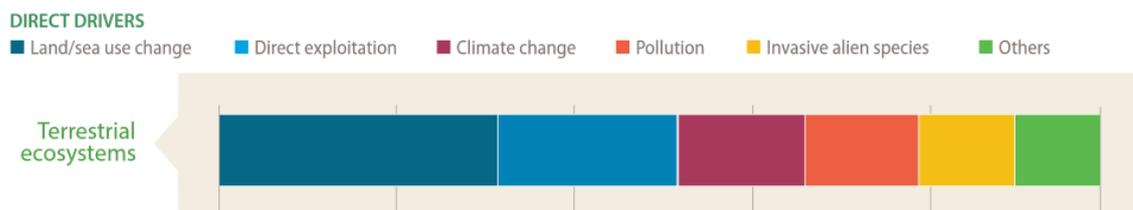


Figure 3: Terrestrial biodiversity loss. (United Nations, 2019, p. 20)

Together with the Kyoto Protocol in 1997, an experimental field for sustainable practices opened up to question and combat the causes and effects of climate change (Bulkeley et al., 2015, p. 32). Then in 2015, with the introduction of the SDG’s, governmental support for sustainable innovation increased drastically. As shown in *Figure 4*, a study from 2015 found that 66 percent of experiments in cities were carried out by the local government and only nine percent by civil society. Yet, niche experiments lead by the local society, such as CSS, can help to address specific problems at their roots and can be seen as experts in their contexts and environments.

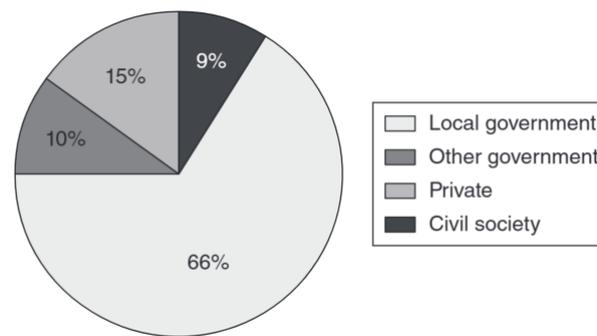


Figure 4: Proportional division of societal actors for urban climate change experiments (Harriet Bulkeley et al., 2015, p. 34).

The aim for a SET is socio-ecological resilience, which means the ability of systems, that incorporate social and ecological characteristics, to achieve a level of adaptability to changes or damage (Marini Govigli et al., 2024, p. 1). As with socio-ecological soil systems, resilience would secure their well-performing. For this, two levels must be taken into account. Firstly, soils health and well-functioning as ecological system in itself. This includes functions such as pH, nutrition, being habitat for a vast number of organisms, feeding plants, sponge functions, and many more (Anthony et al., 2023; Philippot et al., 2024). Secondly, as being part for the functioning of the sociological world in having direct impact on the speed of climate change, the health of humans, control the biogeochemical cycles of the planet, ensuring food supply, and infiltration of stormwater, to call just few of them (Anthony et al., 2023; Schwarz et al., 2022, p. 1).

Here, protecting ecosystems, and soils from anthropogenic damages such as irreversible degradation, massive sealing or pollution, requires the resilience approach with climate change adaptation measures and sustainable development tools, such as CSS (Ryan, 2016, p. 228). Furthermore, social systems need resilience in the form of strengthened trust and reciprocity, which have been lost because our systems have become fragmented and disconnected from the interests of the individual (Moran, 2011, p. 21f). Mark Ryan (2016) points out that resilience

supports the ability of systems to self-renew or self-organize (p.229), where citizen science is trying to take off.

Some important research fields that are closely linked to SET in the literature, or can be summarized under the umbrella term SET, which are also part of the following work, include environmental engagement (Ferreira & Carvalho, 2021), urban and green infrastructure planning (Lampinen et al., 2023), and nature-based solutions (Albert et al., 2019; Breuste, 2019; Davies et al., 2021; Frantzeskaki et al., 2020; Wendling et al., 2018). Further, in the restrictive urban context this would cover topics such as urban ecology or sustainable urban development, and in the societal area it would cover topics such as environmental psychology or social innovation.

3.2 Ethical Premises

Before setting out the basic premises of the case study, it is necessary to highlight the associated ethical foundations and frameworks. These are particularly important in SET, as a variety of perspectives and stakeholders need to be taken into consideration, and the way in which this is done determines to a large extent the success of the project. Although environmental awareness and the impact human beings have on the environment have always coexisted and date back to ancient Greece (Palmer et al., 2014, p. 421), the ethics involved are currently more specific in our common understanding.

It wasn't until 2016 that the spearheading scientist and feminist philosopher Donna Haraway went beyond analysing and understanding environmental issues in her book 'Staying with the Trouble: Making Kin of the Chthulucene'. With the Chthulucene she constructed the idea of an ecological age where all species co-exist and cocreate communally. This can be understood as a response to the observed destructive dynamics of the Anthropocene. According to Haraway (2016, p. 168), it is about an ecological relationality theory that is influenced by the

feminist ethic of *response-ability* and takes seriously the practices, innovations, and experimentation of living creatures in the creation of life and interspecies worlds.

Against this background, the related ethical framework of *care ethics* must be taken into consideration for this study. It is generally understood as a social guideline for the interaction of human beings with one another. It calls for a sense of selflessness for the common good, even at the risk of putting the parties involved closer to the weaker side (Blum & Murray, 2017, p. 22). This concept highlights that there must be more than just liberal individualism for people or societies to thrive. In context of the human-nature nexus, nature should be seen as a stakeholder that society has to take care of. Considering soils, it is soils themselves, with all its diversity, to take care of. When implementing instruments such as CSS and other interventions, nature could even reversely take care for the people in the long run.

Since part of the ethics of care is to view people as social beings, and to understand society and its institutions in terms of the values of care and care behaviour, it is considered a guarantor of well-being (Held, 2005, p. 76). However, as it is not possible to assess the well-being of bacteria, fungi and other organisms as such, we look whether they are functional or non-functional and use this as a measure of their health. In this way, they are comparable with the functioning of ecosystems, where the functioning of the entire system can be described as either healthy or sick. The definitions of health therefore also apply to non-human organisms and ecosystems, which can also suffer from health problems. Consequentially, attention must equally be paid to the health of ecosystems (Ryan, 2016, p. 229). Since governments and political or monetary organizations are often not regarded as ethical institutions due to the goals they pursue and their suggestibility (Held, 1995, p. 29), societies themselves are called upon to take action.

When speaking about socio-ecological issues, it seems almost self-explanatory to also consider *environmental ethics*. In its contemporary understanding, environmental ethics developed in the 1970s through greater socioenvironmental recognition and an academic debate that led to the first conference on the subject at the University of Georgia in 1971 (Palmer et al., 2014, p. 421). A decade earlier, the US-American science journalist and activist Rachel Carson had already advocated for more environmental awareness and protection. In her book ‘*Silent Spring*’, which was published in 1962 and gained great global reputation, she made clear how destructive human interaction with nature is and which impact this also has on the people.

In the first half of the 20th century, the idea that global resources serve the interests of humanity led to economic overconsumption, which was further intensified by industrialization and World War II. Since then, the relationship between humans and nature has expanded to two dichotomous poles. Now, aware of the destructive consequences of human behaviour, environmental ethics then developed, perceived and brought together philosophical ideologies and movements that address this issue (Samuel Bassey, 2018, p. 40). This ethics determines to take the nonhuman world into consideration and to imposing necessary constraints. In this sense the environment is considered a stakeholder.

Environmental ethics is now more of an issue than ever, and humanity is questioning its less-than superior extractivism. As Dawid Wolfe stated in 2002 about soils: “We are beginning to realize what ‘surface chauvinists’ we have been in our myopic vision of life on the planet, blind to all but the most obvious of subterranean creatures” (Wolfe, 2002, p. 3). Emphasizing that people must learn how to deal with the challenges of coexisting and dying together on a broken planet, Haraway (2016) suggests a “sympoiesis”, the incorporation of participation, a “making-with” (p.5), rather than just creating spaces.

Through new technologies and developments, the challenges but also the potentials for environmental ethics are shifting nowadays and a wider range of disciplines are increasingly recognized for environmental ethics considerations (Palmer et al., 2014, p. 434). Even when the ideology of environmental ethics also recognizes that values and principles of sustainability transcend empirical sciences and knowledge of the human environment (Palmer et al., 2014, p. 421), the appropriate understanding of these systems can be important. Specifically in the political agenda, evidence is needed to give environmental ethics a certain amount of proof in decision making, in conflicts of interest, or in implementation of regulation.

Ecosystems, as well as soils themselves, provide a wide range of benefits that can further promote the well-being of life on earth. Several ecosystem benefits can be identified that provide scientifically proven benefits to all life on Earth, taking into account various identifiers (Breuste, 2019; Stinner et al., 2021). Ryan (2016) identifies three main groups to achieve a better understanding of the different areas that comprise ecosystem functions as services: “ecosystem goods, ecosystem services and cultural services” (p.224). With the ability to measure the benefits that ecosystems bring to humans and their future, and with the recognition of their distinct functions, named as services, it provides reasons for their protection (p. 231).

For the anthropocentric world Palmer et al., (2014) define environmental ethics as “the study of ethical questions raised by human relationships with the nonhuman environment” (p. 420). People have to ask themselves what they actively have to change to improve their environment, and where ethical claims provide guidelines and norms that can be followed (Bassey & Nwoye, 2018). But here, a distinction can be made between environmental science in its function to understand natural systems and providing knowledge on the one hand, and environmental ethics on the other, which applies this knowledge to the guidance of human behaviour and decision making (Ryan, 2016, p. 29). Acting responsibly, in harmony with,

instead of overriding nature, presupposes people's willingness of doing so, which requires their consciousness regarding environmental science (Samuel Bassey, 2018, p. 40).

4 Study design and structural underpinnings.

In the following five sections of this chapter, the particular role of the researcher is first contextualized, then the applied overall methodology is presented, followed by its ethical implications.

4.1 Contextualization of the Researcher

For this study, it is worth considering the author's role separately, as it is semi-participatory anthropological research. On the side of being scientist, the author acts as a representative of the OSA association. Thus, she has already conducted and guided several soil testings and is familiar with urban contexts through her constant observations. Her observations and assumptions are based on previous lived research. In this sense, a continuum of application of the previous OSA-work and case study analysis is guaranteed.

In addition, she also works as facilitator and observer in the empirical field research of the study, thus plays an active role in the testing. Even when the whole atmosphere was kept inclusive and open, it needs to be pointed out that participants might be influenced in their social behaviour.

In particular, the author broke out of the conventional paradigm that most academics are seen as. In her capacity as a representative of research, the author took on the role of both teacher and researcher at the same time.

4.2 Implied Methodology: Situational Grounded Analysis

The overall aim of the present qualitative study is to understand the impact of urban soil testing as mobiliser of human actors as agents for an accelerated SET.

This study is mainly based on the methodological framework of Adele Clarke's situational analysis. Nevertheless, elements of the underlying grounded theory (GT) technique are also utilized to serve its own purpose. Further, the researcher analyses assumptions that emerged from her previous observations. Honouring the epistemological foundations of the listed "theory", which is a theory in name only and should rather be understood as methodological tool, she follows an interpretivist-constructivist paradigm to analyse her co-generated data (Grix, 2010; Latour, 2007). To this end, the researcher focuses on the socio-ecological significance of everyday human action in relation to natural sciences and seeks to impart this lucidly through the situated practice of a collective workshop.

In 1967, Anselm Strauss and Barney Glaser developed an open data coding framework as a methodological guideline. In it, the assumptions are analysed based on the data and then categorized and coded to finally develop a theory that illustrates both the researcher as well as the participants (Corbin & Strauss, 2015, pp. 25 & 90). In the further development, Strauss in particular placed more emphasis on pragmatism and interactionism than on the philosophical background to theory, as he believed in the value of theorizing for the transfer of knowledge (Corbin & Strauss, 2015, p. 89). Even though this thesis does not aim to provide a conclusive theory, the coding and categorization reflect the participants as much as the researcher.

The analysis in this thesis mainly follows the ideas of situational analysis by Clarke, who translated the GT approach into a form of "situational analysis: grounded theory after the postmodern turn" (2005). For Clarke, Bruno Latour's rendering of "actor-network-theory" (Latour, 1992, 2007), which seeks to trace reality as a construct of networked action by countless human and non-human agents, plays a significant role in research. By combining the social and the technical world, it also gives space for the non-human to be recognized as an actor with

agency (Clarke, 2005, p. 61). With this essential recognition, she combines GT with actor-network-theory and gives non-human elements material and discursive rights. For this study, soil can be seen as an object of analysis, but it also functions as the centrepiece of citizen science and people's engagement. Thus, it "both constitutes and affects" (Clarke, 2005, p. 72). In it "elements formerly arrayed around the action are now imaged as in the action, as actual parts of the situation of action" (p. 72). This can be seen as a well-suited approach to this thesis.

For creating a situational map, the situational analysis methodology suggests using coded data (Clarke, 2005, p. 84). Consequently, a comprehensive understanding of the context of the case studies factors and the data from the workshop and surveys is required for this.

Before generating the situational map, tree methods were applied. In it, the first step was to conduct literature research where important factors of urban CSS were understood and described. Here, the importance of soils and of engagement, urban green, and a brief snapshot of the current political landscape inform the basis for the following empirical case study.

Then, the applied case study was divided into two steps: First, a field study, a soil testing with the OSA method, has been conducted in Meidling, Vienna. This two-hour CSS workshop was filmed for later analysis. In a second step, feedback was generated in a closing round of the workshop, but also through a survey which participants were asked to answer, and which had been provided to them after the workshop.

As the methodology suggests, the results of each individual research step were first analysed and evaluated before proceeding to the next step and finally creating a situational map, as depicted in *Figure 5*.

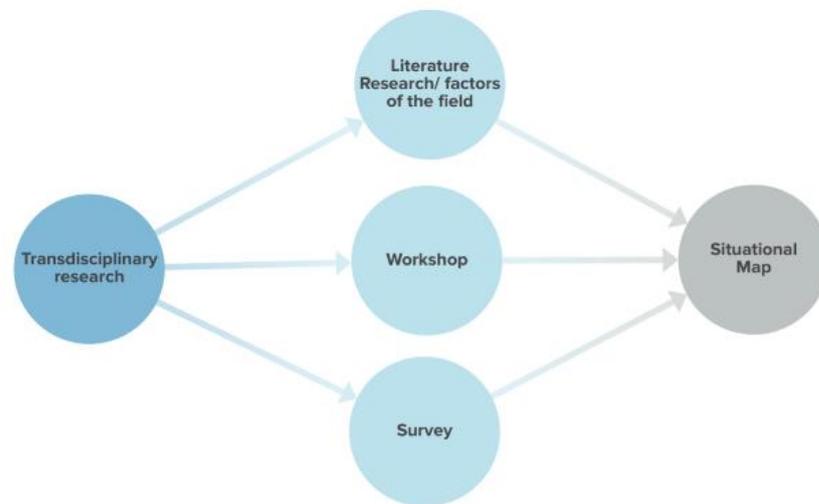


Figure 5: Authors procedure of the thesis

Just then, the situational analysis could be conducted. First, the case study was coded using precise coding and categorization guidelines by Strauss (1987). Following that, Clarke’s (2005) situational mapping process could be applied. With this, an overall picture of the subject was created at the end. The type of “situational map” (p. 86) was used fluidly, based on the authors’ experience. With this, all the relevant concepts, human and non-human elements and actors of the CSS case study were brought together on a map. These results were finally analysed and discussed in conjunction with the literature research and in context of the SET, ethical premisses, and observations of the process.

Through this thesis, soil may be better understood from a whole system’s perspective. Accordingly, CSS is conceptualized as one of the variables for a sustainability transition from the existing state (unsustainable state A) to the desired state (desired state D), as shown in *Figure 1*.

4.3 Ethical Implications

Considering the fact that human participants engaged in the study, ethical implications of the process were considered, that will be described here.

The research design and aim were consulted with the supervisors before being implemented. For the workshop, participation was entirely voluntary, and participants could join or leave the workshop at any time. Beforehand, every participant had to sign an informed consent form. The form provided information about the video analysis procedure and the exclusively academic use of generated data. During the whole workshop a safe environment, free of physical, psychological or social harm, was implemented. The author is aware that no complete safe spaces exist and that this is still considered subjectively.

Optionally, participants were asked for contact data, so that the survey could be sent to them and information about the soil testing and its context be shared in a follow-up message. All participants signed the consent form and additionally gave their contact data. Thus, they received agreed information in a follow-up e-mail, and could then also voluntarily participate in the survey. This also opened with an informed consent form before an anonymous reply was possible. Throughout the whole procedure, no irrelevant personal data was collected, videos were not shared outside of academic use, and participants were treated anonymously. Thus, confidentiality was given at any point.

CHAPTER II – LITERATURE RESEARCH

In this chapter a pure literature research about the elements of the study was conducted. The next two chapters address the closest CSS topics: the importance of soils as a medium, and citizens engagement. Then benefits of urban green infrastructure is be set out as it is the aim of the urban CSS intervention to reach more green spaces. Finally, insights on the EU and Vienna, as place of conduct, are be pointed at.

5 The importance of soils

As the thesis is based on soils, they are presented in this chapter. Their role as an important medium of change is explored to give insight into their capabilities.

“My attitude toward the earth changed when I learned to view it as a living organism.” (Joona, 2023, p. 72)

The whole Planet Earth is encased in topsoil. Still, it is believed that almost half of the world's population lives in isolation from the natural world. This implies that a sizable section of people may likewise be cut off from soil (Mason et al., 2024, p. 2). This giant expanse of life creates unique habitats with various properties and serves as the fundament for nearly all species of flora and fauna (Gamper, 2024, p. 40). Adding to that, soil systems are composed of minerals and organic substances. Depending on its distinct components, as well as external factors, like anthropogenic impact, climate, pH and location, to call just a few of them, they are not always the same and in a permanent mode of transition (*Soil Associations*, 2023). Taking this into consideration and to stimulate an adapted perception, terminologically it will be referred to as soils in the following.

Because of not being as charming as green spaces aboveground, soils are commonly less appreciated in the average perspective in comparison to other ecosystems even when they are such an essential part of life (Gamper, 2024, p. 40). Since the Industrial Revolution they have mostly been recognized when speaking about extraction or construction. Furthermore, they are the matter that is worked with in a close way in the fields of Agriculture, Archaeology or in Soil Science (Vaage, 2024, p. 85). Yet, in 2002, Wolfe provocatively stated that humans can be understood as “surface chauvinists” (p. 3), referring to the fact that there is more than this.

In terms of climate change mitigation, first and foremost, soils are considered and recognized for their ability to sequester carbon (Schwarz et al., 2022, p. 2). This happens through soil microorganisms, species that are diverting from generic taxonomy of flora and fauna because of their individualistic conditions (Julian Chollet et al., 2022, p. 8). These microbes, living inside of soils, convert nutrients and carbon. Additionally, through their various biogeochemical and biophysical mechanisms, they continuously shape the soils habitat (Philippot et al., 2024). Through this, soil-ecosystems provide various benefits to flora, fauna, and humans.

That the total biomass of life beneath our feet is bigger than we can capture with visual experiences or understand with our sense of reality is unimaginable for humans to accept (*A Chaos of Delight*, 2021; Wolfe, 2002, p. 3). Albeit, as “pioneers of life, microorganisms have been established on our planet for c. 3.5 billion years. As a result, plants and animals have co-evolved with trillions of associated microorganisms for millions of years” (Antwis et al., 2020, p. 2). In fact, a recent study from Anthony et al. (2023) estimates an average of 58.5, per cent, with a variance of 14,7 per cent, of living species are deeply depending on soils to survive, (p. 6).

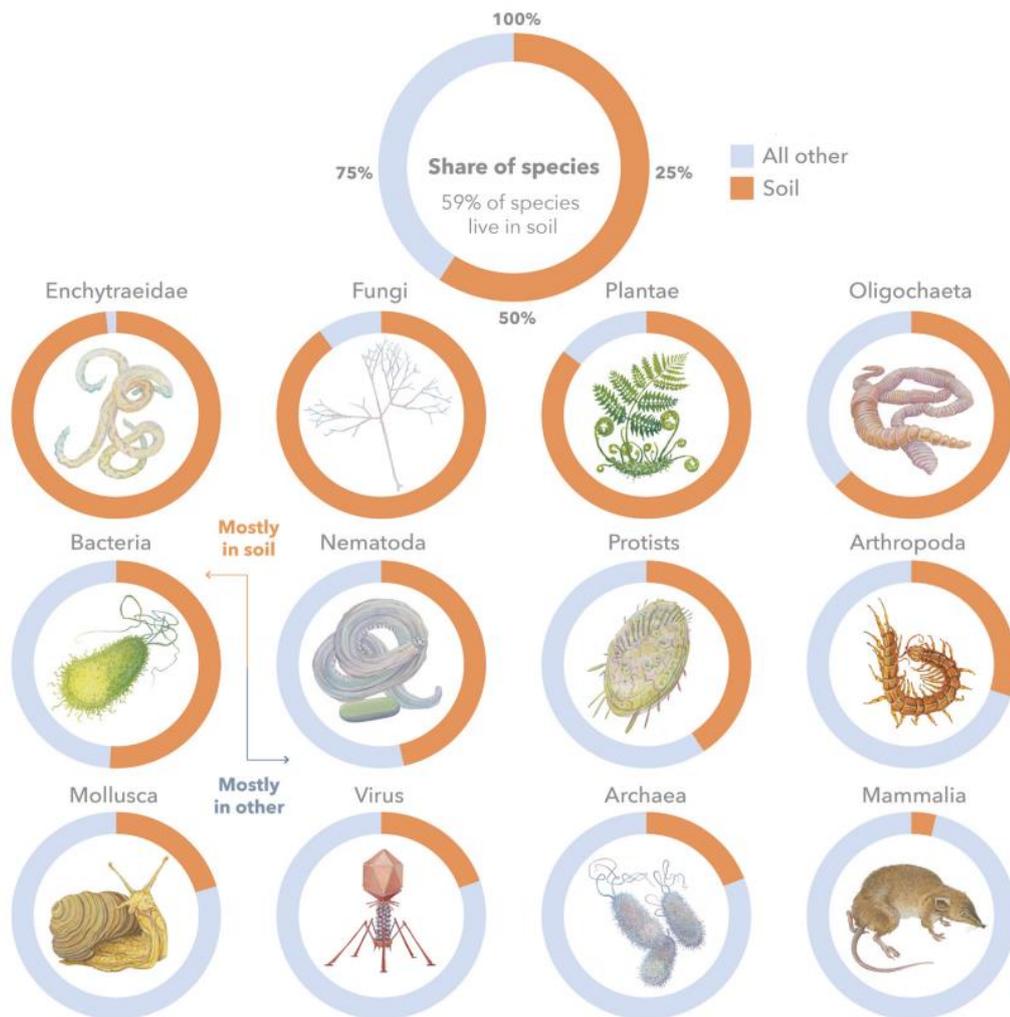


Figure 6: Soil Species Dominance (Anthony et al., 2023, p. 7).

As seen in *Figure 6*, soils harbour a significant proportion of global species diversity, particularly among understudied groups like fungi and bacteria. The orange segments in the donuts represent the percentage of species living in soil, while the remaining segments show the proportion living in other ecosystems. The smaller donuts are ordered from greatest to least soil specialization, with the most specialized groups appearing smaller. Likewise, even more species use this matter to hide, breed, grow and sustain human life.

Soils are complex systems with multi-dimensional roles. In addition to their carbon storage function, some other ecosystem benefits, like water infiltration, the ability to produce food, and their role as a habitat for biodiversity, have already been mentioned before. Further, in

Figure 7, not only ecosystem services by the Common International Classification of Ecosystem Services are specified in the interplay with defined soil functions, but also the underlying soil properties are stated. Given this, it becomes clear how influential soils truly are.

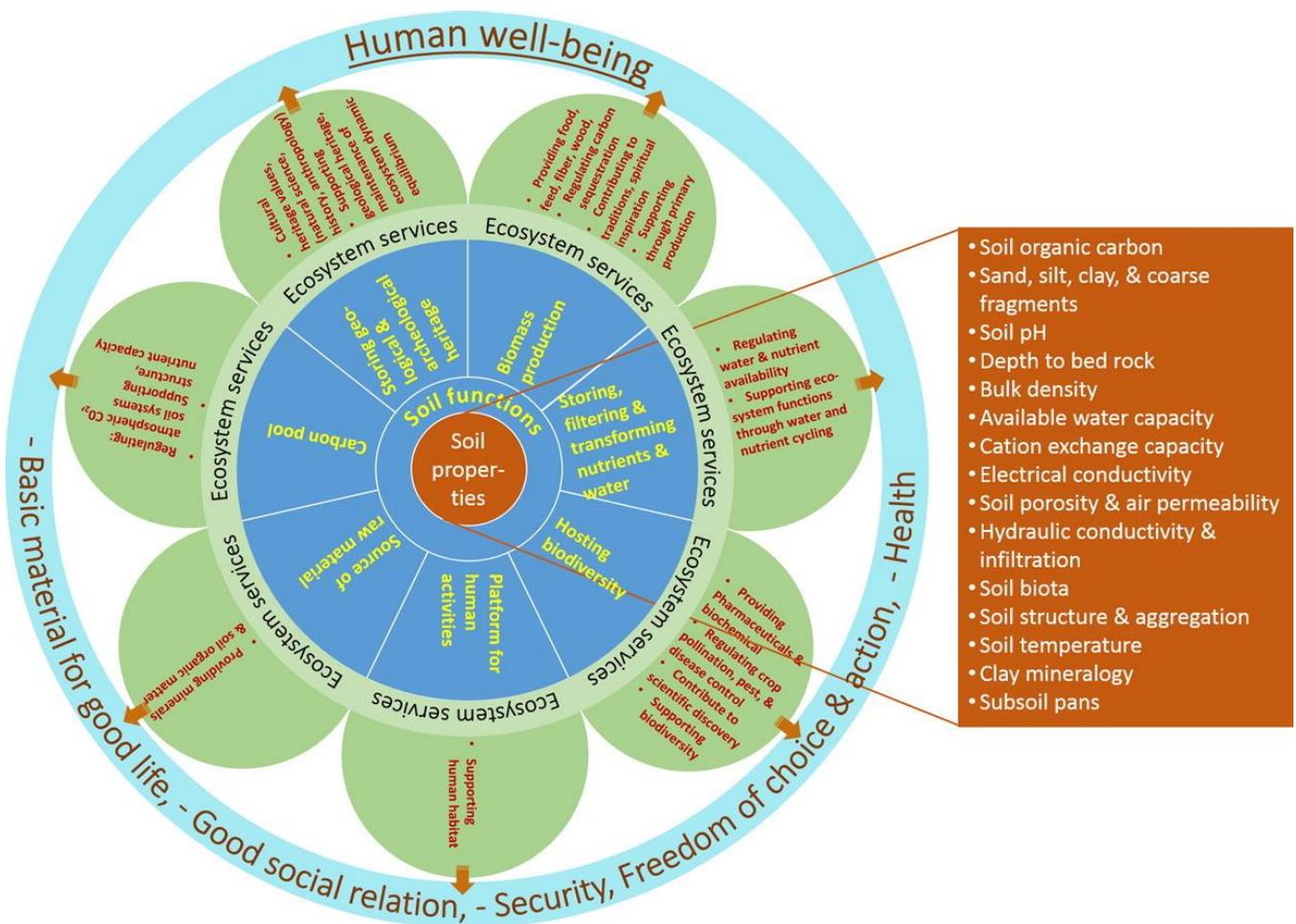


Figure 7: Schematic graphic showing how soil functions for human well-being are linked to ecosystem services through important soil qualities (Adhikari & Hartemink, 2016, p. 103).

Even if it is possible to treat soils organically, for example by recirculating organic material, these microorganisms are under stress because of how the ground is treated and exploited (Shiva, 2008, p. 127). Thus, it is necessary to consider the feedback loops microorganism-soil networks have. The pH value, the amount of organic carbon in the soil, and the partial pressure of oxygen turn out to be important factors in the structure of microbiomes and their activities (Philippot et al., 2024). Surfaces are sealed, ground gets extracted, and industrial agricultural methods destroy its natural structure, their natural nutrition and contaminate healthy systems, besides applying chemicals, all to maximize profits.

Caring for soils is a necessity to prevent desertification, and thus keep civilizations healthy and retain them from collapsing, as historically proven (Julian Chollet et al., 2022, p. 2), Moreover, when improving this living matter and working with it purposefully, it can help to prevent form “eco-evolutionary consequences” (Philippot et al., 2024).

As shown above, soils are scientifically significant in the urge for a sustainable planet, and to pay them more awareness, valuation, and an improved overall protection has increasingly been recognized in the academic community (Schwarz et al., 2022, p. 15). Additionally, in the political arena, soils are being acknowledged as part of “natural capital”, as well as autonomous, significant part of green urban infrastructure, which is stated in the chapter The need of green urban infrastructure below (*Directive on Soil Monitoring and Resilience*, 2023).

When speaking about the average citizen some close interaction with soils might happen with gardening, whereby access to open ground is restricted, specifically in cities. Usually, not the soils, with their ecosystem and social benefits, are at the centre of attention here, nor it is the variety of creatures and species that they provide. Which moreover is in the centre of interest to people are the visible plants, the yield, and the living creatures that are nourished by soil systems. Conversely, they are often still treated as lifeless working material and a necessity to deal with (Vaage, 2024, p. 85). Here, people’s soil awareness, soil protection and soil appreciation is

missing (Schwarz et al., 2022, p. 15). Close interaction with the ground can help to acknowledge the living biodiversity below the surface.

Of course greening initiatives in European cities, which cover a vast number of topics for a sustainable environment, set free socio-ecological changes (Beatley, 2000, p. 38). Yet, even when an engagement with the soil could improve the connectedness of people to the ground, this rarely happens. Thus, soils are usually not the centrepiece of activism. Through broken human-soil relationship, not much is known in the common public about specific details of soil functions, nor of soils ecosystem benefits.

Even when it is said that soil research could benefit from a greater engagement with communities by gathering data on a big scale, it exists a lack of close engagement of researchers with urban communities about this matter. When people would contribute to all steps of exploration procedures this would specifically support the data generation, despite of strengthening their bond to soils (Schwarz et al., 2022, p. 2). With more engagement of citizens with soils, it would be accessible for them to compare different types of soils and generate empirical information (Joona, 2023, p. 73). Even when they might not easily be accepted by the mainstream, (p. 77) a systemic approach is needed to engage people, so that they gain appreciation for, awareness about, and a behavioural change with soil.

Soil regeneration is a slow and complex process (p. 77), fertile soils can be destroyed at once, and sometimes this destruction cannot be restored at all. It needs “more photosynthesizing cover on soil both in urban and rural settings. Less sealed or bare soil. [It] need[s] soil[s] whose microbes, spores, and compounds can be released [...] into the respiratory systems of organisms while water is absorbed by crumbs and pores.” (p. 78) Current interventions are needed to regenerate and store our soils for the future.

6 The importance of Citizen Engagement

Another element which underlays this thesis is citizen engagement, which is discussed in more detail here. It is explained from different points, as well as historically traced.

Facing the multi-crisis Climate Change, with its complex issues, it needs diverse actors that support the process for a Sustainable Transition. Since system changes are complex, they must happen on different levels and in combinations of diverse disciplines (Bassey & Nwoye, 2018, p. 45). Hence, single people are asked to bring in their individual abilities. With an increase of diversity in the system, multiple actors can make decisions in the best overall interests of the different parts of society and of the overall aim. Thus, on the side of the responsible political affairs, it needs citizen engagement.

Underlining this, it can be said that citizens engagement supported the process of implementing environmental ethics into the real world and form a policy direction. Also historically, just when environmental ethics, with its comprehension of environmental responsibility, reached the mainstream, after being issued in the philosophical arena, it came into politics. With this, the understanding was born, that human beings have to be humble and not consider themselves dominant over nature but being more sensible to it (Bassey & Nwoye, 2018, p. 40).

With Ralph Waldo Emersons book-lengths essay “*Nature*” an era of resistance literature, the so-called American Resistance, started in 1836. This set the ground stone for cultural criticism and nature resistance (Reynolds, 2016). Then, with the awareness for non-neglectable environmental issues and the rise of environmental ethics, with its first academic Conference in the University of Georgia in 1971, environmental movements of today’s understanding came up. Even when civic activism was part of the intellectual discourse before, people were now activated to unite in the name of nature, advocate for more environmental awareness, its protection and

preservation. Because of these societal movements environmental ethics with its socio scientific considerations grew (Palmer et al., 2014, p. 421).

In many countries, specifically in developing countries, the environmental agenda is taken care of at the last stage. Specifically, countries such as those in Africa, the Middle East or South Asia often do not have sufficient stability or resources to pursue or implement sensible environmental policies (Bassey & Nwoye, 2018, p. 43). Thus, resistance in a range of forms gets triggered in the civic society. Through the continuous extraction of the planet, and tremendously rising evidence for climate change, many environmental movements raise their voices worldwide. This goes from movements like *Greenpeace*, shaped in 1971, over *Earth First*, founded in 1979, to contemporary movements like *Fridays for Future*, or *Extinction Rebellion* (p. 40) They are calling for more active climate action and a shift in the way how the dominant global politics is led by economy and how environmental issues are not tackled sufficiently.

Over the past 20 years, developing nations have generally had greater control over environmental issues, particularly after the Kyoto Protocol was put into effect in 1997 (p. 44). But even when political instances introduce environmental policies and guidelines sufficiently, it sets free a spiral of time-consuming diplomatic processes. Because of this, implementations can be slowed down, and often just a part of what has been decided in the beginning comes into action. Subsequently, in turn, this stimulates self-organization and ‘civil disobedience’, a term which had been introduced by Henry David Thoreau (1848) in his essay about *Resistance to Civil Government*, as part of the American Resistance movement (Bassey & Nwoye, 2018, p. 41). Emphasizing this, it mostly is environmental movements that ask for more and drastic actions. However, their demands must first go through the political operation, considering different factors like economy, wealth, science, etc. before being considered.

A collaborative effort involving a diverse set of stakeholders, including the public, is necessary to effectively bridge the gap between our current state of knowledge and societal needs (Mason et al., 2024, p. 2). Compared to the indirect ways policy makers tackle environmental issues, societal movements follow the approach to get active themselves and they directly address issues, often from a biocentric perspective, sometimes even by using extreme or illegal methods (Bassey & Nwoye, 2018, p. 41; Extinction Rebellion, n.d.). Through interacting within each other, they pick up new skills (Rottenbacher, 2005, p. 4) and can bring forward their aims. At this level, greening initiatives have an impressive reach and variety of activism and variety in northern and western Europe, from accounting for compact cities, circular approaches, to endeavours to an environmental friendly build environment (Beatley, 2000, p. 38). Besides, the emergence of creative pioneering, transformative innovations and cooperation of research and practical application comes at an ideal moment, with the United Nations' Decade of Ecosystem Restoration underway (Jackson, 2021, p. 2).

Granted that climate change is a multi-crisis, essentially required is the “wisdom of the crowds,” even when frameworks can work as a compass for the shift to sustainability, so that different perspectives are getting included (Olivier Lefebvre, 2022, p. 219). Even when implementing policies or making decisions, policy makers are not able to capture the whole complex construct in oneself and consequently make decisions on their own perspectives, be it on local or international level. Unavoidable, this leads to an restricted decision making process (Voulvoulis et al., 2022, p. 2). An enhanced multi-actor involvement and interdisciplinary inclusion helps for a better understanding of the many layered climate crisis and to find new ways (p. 3). Additionally, considering that civic people, who might be affected by or faced an issue before, are trained in a specific field, or are about doing change, are more likely to provide needed expertise for the certain topic, their perspectives are indispensable, even without being on a high level of agency.

In this regard, besides environmental ethics, also the term “co-production” shaped in the 70th, which rooted in the "participatory turn", the surge in interest in participatory research. It became famous through participatory public service delivery and urban and regional planning. Since then it is recognized and supported by sustainability researchers that complex problems “like climate change, terrorism and loss of biodiversity” (Iokiñe Rodríguez et al., 2023, p. 34) cannot be solved by conventional methods, and need a shift to more collaboration. To face this, the SDG’s are an attempt to understand this interconnected multi crisis holistically and find solutions that integrates inclusivity, “and takes into account social, environmental and economic capital and has the potential to attract public attention and influence public sentiment.” (Voulvoulis et al., 2022, p. 1).

Stressing citizen engagement helps for a better visibility of issues, first by raising awareness within engaged participants, followed by the integration into the common public. Already Margaret Mead and Ruth Benedict, in name of the culture and personality school, brought forward the idea that social behaviour is malleable and culturally determined (*Culture and Personality*, 2017). Therefore, the secret to a successful sustainable development program is a blend of environmental, social, and ethical themes as well as significant community involvement and community participation (Bassey & Nwoye, 2018, p. 45). Like this people are more likely to appreciate the complete ecosystem for a sustainable future and become aware of their own related abilities and limitations.

Knowledgeable, critical-thinking individuals are essential to solve problems in a democratic, dynamic, and varied society (Voulvoulis et al., 2022, p. 5). With a differentiated ecological understanding of soils, people would be more likely to appreciate and thus protect these ecosystems. As shown before, through their properties, they provide functions, that then translate to ecosystem services, beneficial to human beings and other species (Adhikari & Hartemink, 2016, p. 103). As stated in the Ethical Premises chapter, with this, people would

recognize soils differentiated roles in ecosystem goods, ecosystem services and cultural services (Ryan, 2016, p. 230). Hence, people understand their function for ecosystem health and act accordingly (p.232). Ultimately, participatory approaches contribute to the development of a more inclusive and equitable design of green urban infrastructures by uncovering the underlying social and perceived factors that underlie people's preferences for green urban infrastructures across the biodiversity-climate-society nexus (Lampinen et al., 2023, p. 9).

To engage citizens and make them feel empowered, it is required to provide systems thinking in which they learn on their own how to be independent, involved, and knowledgeable (Voulvoulis et al., 2022, p. 5). In order to create a better urban environment, a research by Nahar et al. in 2023 looked at public views, attitudes, and understanding of the sources, impacts, and control of pollution. The study highlights the necessity of educating the public about environmental education to reduce pollution and its effects, as well as the necessity of encouraging people to follow environmental laws in order to save the environment from contamination. Strong correlations with age groups, economic groups, and levels of education were also discovered by the study (Nahar et al., 2023). Change eventually begins to impact the overall configuration of the system due to positive feedback loops that activate as consumers grow more accustomed to the new paradigm, green infrastructure being built, complementary innovations entering the market, and more favourable policy and regulatory frameworks being put in place (Voulvoulis et al., 2022, p. 4).

Adding to that, a community feeling with a sense of belonging and trust, through local citizen engagement, helps for resilient actions. Emotional co-responsibility stemming from real experienced situations improves the foundation for relationships, which in turn fosters trust (Rottenbacher, 2005).

While people find values such as kindness, advice and belonging when interacting within a community, they may also be the least vulnerable due to close co-operation and the

ability to react quickly and deal with unexpected circumstances, thus more resilient (Moran, 2011, p. 21). Considering Ryans *Precautionary Ecosystem Health Principle*, which has already been introduced before, it needs research and risk assessment to demonstrate a causal link between dangers and solutions besides of “self-organisation, self-renewal and resilience” (Ryan, 2016, p. 232). It is less likely that people will act against risks without probability estimates, which makes them crucial for the effective implementation of the *Precautionary Ecosystem Health Principle*.

Still, libertarian and paternalistic answers are shown to be insufficient, while a deliberative democracy, supported and led by post normal science, is a significantly better foundation for directing the *Precautionary Ecosystem Health Principle* (p. 231). In this regard, it should be aimed for “‘good enough’ answers” for more civic participation in science (Jackson, 2021, p. 1086). These might then be more accessible and effective instead of huge budget, ambitious scope, and significant stakes. Experimenting with citizen science, initiatives entail working with communities to involve them in data classification, collecting, and cocreation. Still, there is no formal definition of the field's techniques and debates over what kinds of actions and practices go under this broad heading (Mason et al., 2024, p. 2).

7 The need of green urban infrastructure

For the aim of CSS to reach liveable cities, green infrastructure is targeted. Its importance and effects are set out here. Together with different concepts that are common in this regard.

In 2019 the United Nations stated that the already existing 50 per cent of the worlds urban population will grow up to 70 per cent by 2050 (p.71), which leads to urban growth into suburban areas, informal settlements and an overuse of existing and new infrastructure. Besides, these spaces have enormous footprints on ecology (Beatley, 2000, p. 3). For urban liveability and well-

being, they identify climate resilience, a secured biodiversity and “naturbanity” (United Nations, 2019, p. 84), where urban citizens live in symbiotic conjunction with nature besides of other services. As shown in *Figure 8*, Lehmann (2011) delved into green urbanism, where for its achievement he identifies tree intervened principles.



Figure 8: Green urbanism with its tree main pillars and their interaction (Lehmann, 2011, p. 106).

As one can see in *Figure 5*, green urbanism supports troubleshooting the many current issues in cities. Integrating nature-based solutions, as well as green infrastructure in the design

of cities provides multifaceted benefits in every layer, from soil to the tree canopy, from ecological to cultural (Beatley, 2000; Lehmann, 2011). Examples for green infrastructures are unsealed surfaces for flood mitigation, which can soak up water, which might then even be filtered by a well-working soil structure before filling up stressed urban groundwater levels. Beds with plants, which can provide water transpiration through their biomass while plants also provide shade support with air filtration and lower noise (Beatley, 2000, p. 211). Besides, urban nature can function as habitats for all kinds of animals and for citizens, while potentially delivering yield (Schwarz et al., 2022, p. 1).



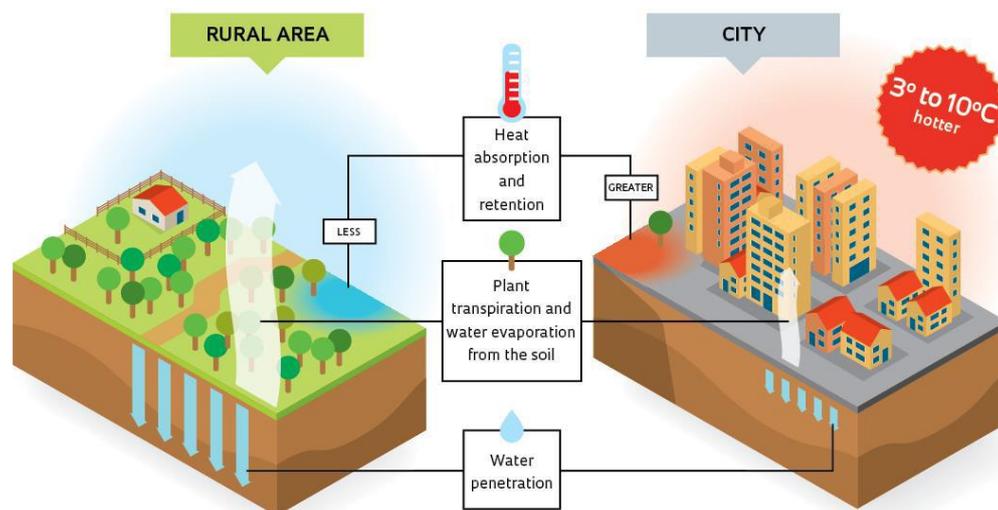
Figure 9: The four fields and 15 principles of green urbanism (Lehmann, 2010)

Under the severe urban issues some exemplified urban ecosystem errors can be looked at in detail here, which are closely connected to stressed soil systems. Due to sealed surfaces and other pavements, water is blocked from going down the soil, which consequentially can lead to floodings (Birch & Wachter, 2008, p. 288). Natural flood management concepts like

green infrastructure development, sustainable drainage systems, or sponge city, where water is taken up, stored, gets into, and is cleaned by the ground, came up in the experimentation for problem solving (Bian, 2024, p. 156).

Additionally, cars, that are parked on the sealed parking lots and streets, reflect heat and conversely are heating up the surroundings alongside polluting the air. Heat island effects, as in *Figure 10*, are a big issue in cities all over the world (Beatley, 2000; Birch & Wachter, 2008; Lampinen et al., 2023). This effects different cities differently, as for Athens an increase of 8-10°C is found (Lehmann, 2014, p. 6), the United nations (2019) state that heat island effects can be up to 5°C compared to rural areas (p. 85).

Why the urban heat island effect occurs



GRAPHIC: ALEXANDRE AFFONSO

Figure 10: Reasons of the urban heat island effect, comparing rural to urban area (*Planning Cities to Better Manage Rising Temperatures* / CSIR, n.d.).

Following the integration of an “Expert Group on the Urban Environment” (Beatley, 2000, p. 16) for “Sustainable Cities” to the European Commission in 1991, a “European Sustainable Cities and Towns Campaign” was approved at a conference in Aalborg, Denmark in 1994. In this conference the so-called *Aalborg Charter* was designed to set some rules in the

fight for local sustainability. In it the “maintenance of biodiversity; human health; as well, as air, water, and soil qualities at standards sufficient to sustain human life and well-being, as well as animal and plant life, for all time” (p. 481) is specifically pinned down. Besides, “natural capital, such as atmosphere, soil, water, and forests” is stated to be endangered and to be invested in, whereby its conservation is highlighted.

Just from the 1970’s, together with the development of environmental ethics, sustainability decision making came up as a key topic in politics. However, not all issues for liveable cities have been addressed yet (Voulvoulis et al., 2022, p. 4), and in many Western countries the dichotomy between ‘civilization’ and ‘wild nature’ is still at stake (Breuste, 2019). This is often caused by the fact that potential green and blue infrastructure is under pressure or even endangered due to infrastructurally limited space resources. Specifically, in this context socio-ecological decisions are underrepresented. Thus, quantifying ecosystem benefits can provide monetary and economic validation (Breuste, 2019; Lampinen et al., 2023; Ryan, 2016).

In a study of 2021 Stinner et al. published a report, where they worked with transdisciplinary real laboratories and afterwards were “capturing the multidimensional value of urban green spaces”. Within they put out regulating ecosystem benefits and cultural benefits. The former identifies food production, water regulation, air pollutant retention, carbon regulation, temperature regulation. The latter addresses urban green spaces as a location for social and cultural events, recreation, environmental education, enjoyment, and urban residents' awareness of the biodiversity that gardens and parks support (Stinner et al., 2021). This shows that ecosystems can provide several benefits that are measurable.

As stated before, cities are an enormous lever in the battle for a sustainable future on the globe (Beatley, 2000, p. 21). In particular, it needs clear matters like engagement, big-scale

quantitative parameters and measurements for green infrastructure to make ecosystem benefits visual and could increase the appreciation for green areas in society and administration. This in reverse, holds the potential to improve quality and quantity of green spaces, as well as their maintenance and could help developing sustainable practices (Stinner et al., 2021, p. 31).

8 Current political soil landscape in the EU and Vienna, Austria.

From zooming in, Europe, Vienna, Meidling, are the landmarks which are providing a political framework for the reputation of soils. Here, the current situation of soils and their recognition is addressed.

In 2021 the EU Mission introduced “A Soil Deal for Europe” with the goal “to establish 100 living labs and lighthouses to lead the transition towards healthy soils by 2030”. The capacity of soils to support ecosystem services is recognized in it (*EU Mission*, 2024). By supporting transdisciplinary engagement and establishing a community through a platform and a manifest the aim was to find concrete solutions for the topic. Henceforth, the European Horizon, the research and innovation funding program which also financed OSA, supports this specific mission financially (*Horizon Europe - European Commission*, 2024). Also other urban sustainability-focused research institutions and initiatives have benefited from the assistance granted by the EU. Another example which has been financed by EU fundings is the European Academy of Urban Environment from Berlin, which is largely concentrated on urban sustainability research, teaching, and information sharing (Beatley, 2000, p. 37).

Following this, the European Commission suggested a “Soil Monitoring and Resilience Law” in July 2023 to guarantee high standards of environmental and health protection, as well as fair playing fields, in support of the European soil strategy for 2030 (*Directive on Soil Monitoring and Resilience*, 2023). With this they want to tackle several issues like “erosion,

floods and landslides, loss of soil organic matter, salinization, contamination, compaction, sealing, as well as loss of soil biodiversity” (*Soil Health. European Commission, 2024*). Further, in February of this year, the European Council and Parliament decided to create a certification system for carbon reductions inside of the EU, as an action to reach climate neutrality in 2050, namely the European Green Deal. This strategy also includes carbon farming with soils (Council of the European Union, 2024). However, as elaborated before, soils in Europe and throughout the world are under threat, although it is essential to preserve their health.

Vienna has a compact urban structure, with a wide amount of green spaces surrounding it and more than a thousand parks covering 13 square kilometres of the city (Beatley, 2000, p. 31). This makes it easy for residents to reach natural spaces in just a short amount of time (Beatley, 2000, p. 31). However, nature is still suspended from the grey infrastructure and not an integrated part of it. The compactness of the city comes with conflicts of use of open spaces and the disadvantages of sealed surfaces described above, like a risk of flooding, a decline in soil organisms and most dominantly for humans the heating islands effect.

The city has a long history of pedestrianization, resulting in the development of new public areas and a steady rise in these city centres’ charm (Beatley, 2000, p. 118). They started offering financial assistance for greening courtyards in 1982 through the Green Courtyards initiative, which by 1990 had improved more than 2,400 courtyards with green features (Beatley, 2000, p. 230). Even when this dates are overrun, and degradation keeps on going, this example explains the tendency of the local government and today’s approx. 50 per cent total urban green (Stadt Wien, n.d.-b).

Although Vienna’s official website provides information under the topic “Environment and climate protection” on specific subcategories such as energy, water, noise and air, as well as parks and gardens, environmental protection, and forests and agriculture, a specific one for

soils is not provided (Stadt Wien, n.d.-c). None the less, in the environmental protection category comprehensive information about ambitious development plans and already running projects is provided. This includes a link to a map of specific environmental data about Vienna. This map depicts comprehensive information about different characteristics of soil, soil pollutant assessment, pH-values, properties, and compositions (*Wien Umweltgut*, n.d.; see index C). Mainly eight types of soils are showcased, that happen to occur in Vienna (Stadt Wien, n.d.-a).

Furthermore, the Federal Environmental Agency directly addresses Soil and Spatial Development and introduces a data monitoring tool (*Umweltthemen*, n.d.). Also here, a new data model for identifying land use and soil sealing in Austria has been created, as part of their soil strategy and on behalf of the Austrian Spatial Development Concept (ÖROK). Data for 2022 works as the output year of data (*Methodik ab 2022*, n.d.).

Still, even when this data is available, this data is provided by the state and doesn't integrate the civic society. People rarely are addressed about this matter and its benefits or the potential it provides when they acquire it and take over ownership.

CHAPTER III – CASE STUDY EXECUTION

This chapter sheds light on the applied case study where first, the key stakeholder groups are presented as a basis. This will be followed by the specific design and implementation of the two methods of the case study with their outcomes. Then the situational analysis is laid out.

9 Key stakeholder groups

In order to analyse the direct impact of CSS on the citizens, an OSA workshop was conducted in the Meidling neighbourhood. In the following, the two main stakeholder groups central to the case study are presented.

9.1 Place of conduct: Meidling

For the case study the neighbourhood of Meidling was chosen. This makes the 12th district of Vienna with a mix of densely populated ex labourer's quarters, residential areas, and a former stately castle, besides of Meidling station, Vienna's western railway junction. With a high birth rate, it is a district with a rapidly growing population. Still, the percentage of people entitled to vote, and of academics is low, while there is a very high proportion of people registered as unemployed (per 1,000 inhabitants aged 15 to 64), in relation to other Viennese districts. It is also interesting to note the low density of cycle paths, dogs and visitors. In addition, there is a comparatively low share of grassland and water bodies, which contrasts with a high share of traffic areas as an indicator about life quality in ecological aspects. Additionally, the district invests double the amount of money for the development of for streets and traffic compared to the ones for parcs, playgrounds and swimming areas (Landesstatistik Wien. MA 23, 2022; Stadt Wien. M53ber, n.d.).

Here, a few proactive neighbours got involved and formed the association *Mei Meidling* with the goal to improve the quality of the built environment from both, an ecological and a social perspective. As a result, in-depth exploratory research and development for an

architectonic climate adaptation measure for more sustainability and liability was carried out from November 2021 to October 2022 (Forschungsförderungsgesellschaft, n.d.; Mei Meidling, n.d.). Even if the architectonic implementation has not happened yet, a participatory exchange between residents and politicians, as well as public administration, businesspeople, and experts has already been explored (Grünstattgrau, n.d.). The association is now advocating for change and it is crucial to maintain the support of the neighbourhood in order to realize the vision of a complete, future-proof shared communal living space (Mei Meidling, n.d.-b). As a result, this neighbourhood provides an intriguing setting to understand how people interact with and relate to their environment through the particular theme of soil.

The aim of the CSS intervention is to openly reach out to the Meidling community to get active. Additionally, in the process, the aim is to increase awareness and education about the benefits of healthy soils and urban green, and ultimately create a place worth living in.

9.2 Facilitating association: Open Soil Atlas

With the aim to establish a food forest, based on social and ecological permaculture principles in the centre of Berlin, the grassroots association *Feld Food Forest*, of which the author is part of, has been formed in Berlin. Their aim is to co-create change, strengthen the human-nature nexus, and foster a culture of cooperation, empowerment and knowledge sharing (FELD FOOD FOREST, n.d). Even when their urban garden could finally be realised, the association had difficulties finding a suitable location. During the process, it was not easy for the private initiative to find accessible places within Berlin, besides they realized that the required data of the urban soil was inaccessible to the public.

Therefore, they developed the OSA, as a participatory "open-source co-learning centre" for citizens in 2021. This half year pilot project was funded by Horizon, an European research and innovation funding program (*Horizon Europe - European Commission, 2024*). As measures to address complex climate change problems are often costly but not sufficiently successful

(Harriet Bulkeley et al., 2015, p. 22), simple solutions are often favoured over complex technologies in small communities (p. 24). This also unleashes "an urban world of climate experimentation" (p. 30), where CSS can be seen as example for this.

With the aim to identify uncommon greenspaces, assess the quality of the soil and engage with people all over the city OSAs methods were developed. Within, soil data gets collected in a digital application, which then generates a high-resolution soil map, and involves and empowers citizens, while making those data available to everyone.

In accompanying workshops, citizens were taught to conduct soil tests, record observations, analyse data, and draw conclusions themselves. In addition to raising residents' awareness of soil topics such as unsealing, planting possibilities, heat islands, etc. are also promoted (Busnardo et al., 2022). The idea of the workshops was not only to raise awareness among citizens, but also to generate a healthy community around healthy soils.

With the OSA methods, only easily accessible tools such as a shovel, water, a clean jar and a little vessel, and a mobile phone are needed to test the soil, see *Figure 11*. The citizen scientists download the *Epicollect* application, a mobile application for data collection in citizen science. This tool is trained by OSA with their soil testing protocol and instructs the citizen scientists, assists them in drawing conclusions on certain soil properties, while capturing the soil data they collect. From the participants' observations and uploaded data, a high-resolution soil quality map is automatically created, which you can see in *Figure 12*. All details and the single results can openly be accessed on the [OSA website](#)¹.

¹ Klick on "OSA website" to get to the OSA web page.



Figure 11: Necessary tools for the testing (Open Soil Atlas, 2021, p. 1).

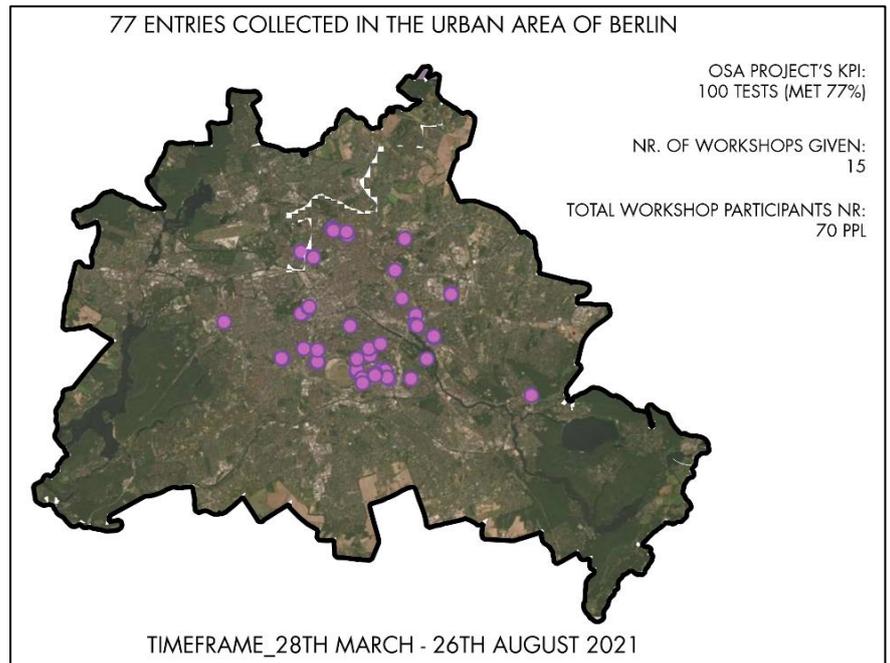


Figure 12: Photo of the generated Berlin map by the end of the OSA examination time in 2021 (Busnardo et al., 2022, p. 29).

The process starts with the highest zoom factor of a satellite image of the selected location, then the citizen scientist's attention is drawn to the surrounding terrain and its features, after which they are guided to make observations at the soil's surface, and only then they dig a hole and learn how to collect information about the soil's fertility. As you can partly see in *Figure 13*, the soil testing protocol² gathers information about: GPS location, land use, anthropogenic impact (in terms of non-biodegradable human litter), soil erosion, biological activity (in number

² Klick on "soil testing protocol" to get to the OSA web page, section "Overview of tests".

of rain worms), soil profile, soil colour, soil texture (ribbon method), soil texture, and the soil pH (Busnardo et al., 2022).

1 Find the Open **Soil Atlas ACTION 2021** Project on youEpiCollect App

2 Select **+Add entry**

3 Enter an Entry Name in the form: **Nickname, Today's Date**. Then click **Next**

At any time, you can navigate through the test to change or correct answers with the **Next** and **Prev** buttons!

4 Enter the soil coordinates by clicking **Update location**

5 Select the **Land Use** from the available options: Here are example images to guide your selection.

5a If you selected **Green area**, select the specific type

6 Add any other notes (optional)

7 Take or upload up to four photos of the area facing approximately to the North, East, South, and West

8 Record the **anthropogenic impact** (human pollution) in the area. Here are example images to guide your selection:

8a If you selected **Massive** or **Relevant**, then record the type(s) of pollution

8b If you selected **Other**, then add some notes of the type(s)

Figure 13: First parts of the soil testing manual (Open Soil Atlas, 2021, p. 2-3).

10 Case study methods: OSA meets Meidling

For this study the CSS intervention is perceived as a driver of change. In order to better understand the case study and the workshop dynamics, each of the two empirical methods, first the workshop and then the survey, are described in more detail here, together with their outcomes. Since this study is about the societal reception of the participants also the blog entry, which had afterwards been produced by Mei Meidling, will be part of the outcomes.

10.1 Method 1 – Workshop design and implementation

„Teach the children. [...] Stand them in the stream, head them upstream, rejoice as they learn to love this green space they live in, its sticks and leaves and then the silent, beautiful blossoms. Attention is the beginning of devotion.” (Oliver, 2019, p. 8)

The focus of this study was the conducted CSS workshop. In this way, the neighbourhood was closely introduced to the details of soils and citizen science, and it was possible to observe their interaction. The workshop format developed, the scientific data gathering, and the OSA methods were used as a tool for soil analysis in the one-time testing.

10.1.1 Workshop – Population and sampling

Actors involved were the already presented key stakeholder groups OSA and the neighbourhood of Meidling. From the latter, a total of 14 people took part in the workshop, including three boys under the age of 14 and a girl aged three. All participants were from the neighbourhood of Meidling, three parents with children, a couple, an individual participant and the lead of *Mei Meidling* were part of it. Further details and characteristics are summarized in *Table 1*. In addition, incidental passersby came by, observed the process, showed interest, asked about the content, or partially participated.

No.	Gender (F/M)	Suspected age	Characteristics	Group
1	F	50s	Alone; active in an urban guerilla garden in Meidling	A
2	F	60s	Married with No.7; Care for a tree grid	A
3	F	40s	Mother of No.4; Indian;	B
4	M	11/12	Son of No.3;	B
5	M	30s	Student of Microecology; Just moved to Meidling;	B
6	M	40s	Alone; Active in sustainability initiatives;	C
7	M	60s	Married with No.2; Care for a tree grid	C
8	M	18	Active in <i>Mei Meidling</i> ; Presented his prescientific research about <i>Klima-Grätzl</i> in Vienna;	C
9	M	30s	Father of No.10; Part of the "Biodiversitäts-Grätzloase Mandlgasse";	D
10	M	8	Son of No.9;	D
11	F	30s	Mother of No.12 & No.13; Geologist;	D
12	M	8	Son of No.11	D
13	F	3	Daughter of No.11; supervised by father;	D
14	S	50s	Lead of <i>Mei Meidling</i> ; Brought drinks and snacks;	X

Table 1: Participants demographics, including special characteristics

The workshop had been promoted through the channels of Mei Meidling beforehand. Thus, all participants were from Meidling, while some of the participants were already engaged with Mei Meidling, with other initiatives in the district, or like No.6 even beyond. Yet not all of them knew each other, including No.5, who had just moved into the neighbourhood.

10.1.2 Workshop – Analysis

Direct observations of the focus groups and on group dynamics, emerging themes, and behavioural observations were made for the analysis. Therefore, notes were taken during the opening and the closing rounds, and the entire workshop was filmed to ensure subsequent analysis of each subgroup. During the video analysis, the relevant sections were transcribed. Parameters for observation were: The level of impact of soil contact on public environmental (social and ecologic) perceptions, attitudes, and awareness, and the interactions in the group. For example, the order and frequency of interactions was observed, or the structure and content

of the conversations, which topics came up and who took on which role. The notes were collected in form of a cross-tabulation to better understand development of social behaviour and topics in relation to the workshop aspects.

10.1.3 Workshop – Design and outcomes

The workshop was well visited, so the condition can be seen as ideal because in being sunny but mild. Specifically, when working with soils, good weather is a prerequisite for a well-attended outdoor activity which was given. The two-hours workshop was divided into six main parts at two different locations: The Introductory round, the walk to the next location, the soil samplings, the joint sample analysis, and the closing round. Thereby, the testing was conducted in a fenced area, which included a playground, wherefore several children were present and could move around independently.

All over, the lead of the Mei Meidling association, No.14, moreover, supported the realisation of the CSS, was caring for the wellbeing of participants, by providing drinks and by mediating between facilitators, neighbours and onlookers. Some of these joined in part and are forming the actor group of pedestrians.



Figure 14: Introductory round at the first location.

Introductory round: The introductory round (*Figure 14*) lasted 30 minutes and took place in *Mei Meidling's* “Biodiversitäts-Grätzloase Mandlgasse”, a small urban garden that transforms two parking lots in the street into green spaces with seating niches. This location was chosen to illustrate the sealing of the city and the alternative use of the street. The group dynamic was open, and participants were welcomed individually by the facilitators.

When no more people joined, a circle was formed unassisted. The facilitators began by introducing the topic, inviting participants to ask mixed, quantitative and qualitative questions directly to the group, and by guiding the exchange. In doing so, the facilitators ensured respectful and supportive encouragement, as well as a comfortable atmosphere. The introductory round followed a guideline that presented some educational in advance (see index A). Here, several soil functions were introduced, citizen science discussed, and the history of the OSA engagement disclosed.

Through this guided introductory round, a mutual understanding of the field was created, and the group shared their perspectives on the topic. In addition, everyone could feel and understand the dynamics of the group, and “co-responding structures between participants” (Rottenbacher, 2005, p. 2) could be established.

The young participants beneath fourteen were highly engaged and raised their hand more frequently than the older participants to reply to questions. When it was asked about defining citizen science, No.5 could perfectly describe it to the group and even come up with examples from a school activity. Also, the young boy, No.12, mentioned his observations about nature and the importance of water drainage during the discussion. He even insisted in the importance for an intact nature, as it would be a habitat for animals and insects. Following this, he connected the rainwater issue with rain worms, suspecting they might not be able to escape the rain when bumping against detonated surfaces. The two boys instinctively mentioned some soil functions and were then supported by the facilitators, and additionally confirmed during the workshop.

When participants had to download the application, it was the younger participants, specifically No.4 and No.8, that helped at this stage.

First, a mother, in her 40s with her two boys, about nine and twelve, stopped by during the introductory round. She showed a high level of interest and gave some input about her lived experience when it came to surface sealing, raised the issue of gravel beds, which are low on biodiversity, and expressed her anger at the wrong decisions made in politics and planning. They joined along the walk to the next location, where they then had to leave. Besides, several passengers stopped by from time to time, observed the situation, or asked why people would the group was digging in the soil.

Change of location: After the introductory round, the entire group changed location. Therefore, the group organized themselves to carry tools and other material and then moved five minutes from the meeting point down the street to the next location.

During this phase, the two boys of 8 years, No.12 and No.10, were running in front, the older boy No.3 talked to another woman about the fact, that he had eaten a rain worm once, and No.7 was presenting their (together with No.2) tree grid the group was passing by.

The test location was a fenced park with a playground area, a table with benches, some trees, and a sandy surface with some flower beds on side of the fences, as can be seen in *Figure 6*. During the process, the established group dynamic from the semi frontal introductory round was able to loosen up and new connections were made. At the new location, the group came together again around a table.

Soil sampling: The entire soil sampling procedure lasted about an hour. On arrival at the meeting point, participants were asked to form four subgroups themselves, so that two subgroups could be supervised by one facilitator. Each team consisted of three to four people. Within the

subgroups, children stayed to their parents, so that the social structure of families was not broken, besides of the married couple, No.2 and No.7. Other than unforeseen guests or kids moving between subgroups, these stayed the same during the time of sampling.

They could then decide on a location where they wanted to conduct their soil sample and spread out across the park, as shown in *Figure 15*. When they finally found their position, they were guided through the soil test protocol (*Figure 13*) using the OSA method, which is described in the previous chapter. Even when the mobile phone guided the participants through the soil protocol, some entries, such as the different levels of pollution, erosion, colour etc. weren't clear, so that the facilitators guidance and the printed user manual were helpful.



Figure 15: Position of the four soil sampling subgroups (A-C) in the park.



Figure 16: Test location A



Figure 17: Test location B



Figure 18: Test location C



Figure 19: Test location D

During the sampling a group of children, about 5-8 in number and from 4-15 in age, joined and were predominantly involved in sampling the soil at location A (*Figure 16*), they were however also moving along other sample locations, or played on the playground. One of the girls was keen on staying and expressed that she “really f[ou]nd it interesting”. They were tightly packed around the hole. The two older people, No.1 and No.7, who tested here, gave them space to discover and concentrated on entering the results into the mobile phones and supporting them. No.7 for example gave tips how to put more weight on the shovel so that they could get deeper.

All participants found a high amount of trash in the bushes and when it came to the question of making photos to the different sky directions. At location C (*Figure 18*), a high level of food waist in a plastic back was found and was a topic of indignation. At location A, the facilitator asked the children to direct north, whereupon they were showing in front of them. Then she asked them to turn around and show north again, thus the children showed in their front again and understood that they had to recalculate the sky directions.

Generally, children were interested in what they would find in the ground. For example, the two boys and the little girl at location D (*Figure 19*) couldn't wait to dig and even started before the application asked for it. Still, they had to follow their parents' instructions and share the activity between each other. When son No.10 hit a tree for fun, No.11 admonished him: "Don't slap the tree, you hurt him".

Also, the children at location A, had to share shovels so that everyone had the chance to dig, which was a recognisably hard to them. They predominantly were focusing on finding worms. Only one boy, around 5 years old, was showing disgust for touching worms although he didn't stop trying. However, the children at hole A and at hole D were thought to make a bed for the worms and in general everyone had to dig carefully.

At location B (*Figure 17*), which was directly on the eroded walking area, they figured out that the park once had been a swimming area until 1976 and had then been introduced as a park in 1984.

Joint sample analysis: After the samplings steps on the locations were conducted, the subgroups reunited at the meeting point to do the next sampling steps together. This process, which is exemplified below, took about 15 minutes.

To carry out the tests, they brought soil samples and jars with some mixed soil. Then, the facilitator explained the procedure and showed with her own hands what to expect. This involved a soil ribbon method, touching the soil for texture, a vinegar test to determine the pH tendence, and a jar test for percentage of each component. It was decided to do this together to allow better comparability of the different soil types and to foster exchange between the participants. With this approach, it was possible to create a "shared experience" and a "common experienced reality" (Rottenbacher, 2005, p. 3).

With high competing ambitions, No.6 secretly had taken soil from another hole, because he wished for “better results” in the *united sampling*. Noticing by colour the other participants of his group noticed it and intervened. When this situation happened, elderly people taught the children how important it is to gather different data for comparability and that through this the subgroups are united, also referring to the high competition in worm count. The jar test was recognized by the facilitator in representing the swamp effect of soils in miniature when water was put on top of the soil sampling and slowly made its way through the pores to the ground.

During this time people were talking, and also exchanging about other topics. No.1, who was part of an ex-guerilla garden that organised a Summerfest, invited other participants to join, including No.5, who just recently moved to Meidling. When No.1 also invited No.14, they were fostering a closer connection in the future. For the Summerfest, No.14 suggested to promote this in their network.

Also, official communication channels of Mei Meidling were discussed, when No.6 and No.2, both from different age categories, reached out to No.14. Here, No.6 advocated for using a social media tool that themselves works socially just and independently, whereas No.2 drew attention to the need for easy accessibility.





Closing round: After completing the testing protocol, a 15-minute closing round was conducted, in which the participants gathered in a circle, again without guidance. The exchange was also led by the facilitator and introduced with the question: “What did you discover?”. One by one they gave their input and responded to each other. When in the *introductory round* it was mostly the children who raised their voices, in the *closing round* moreover elderly people spoke, and it came to a discussion where everyone expressed their learnings and joy. However, No.3 and 4 had to leave before, and No.9 was not so involved due to his child No.10, which was playing around and had lost concentration. Several people shared to be “happy about the total amount of worms, and excited about the strong reaction soils made with vinegar” (*Figure 21*). Overall

people were surprised about the high quality of soils in an urban playground. Discovering insects and other things in the soils was commonly seen to be “something new” or “nice to feel”. Here, No.4, who studied Microecology, shared that “it was something new, because [he] usually work[s] in the laboratory”. Besides, the interaction was appreciated, and No.14 was happy that she could get into contact with the local children and how much interest they showed.

In order to provide ideas for an alternative urban design for a liveable neighbourhood, participant 13 presented the results of his prescientific work, (Figure 20). In it, he examined the logistics of implementing a *Klima-Grätzl*, a traffic-calmed areas, in a specific Viennese district. He also brought printed material, and later emphasized the importance of citizen engagement for advocacy. In addition to the official workshop closure, some people stayed about fifteen minutes over the official end to connect, ask questions.



Figure 20: Presentation about the *Klima-Grätzl* concept by participant 13.



Figure 21: Reaction of soils with vinegar

10.2 Method 2 – Survey design and implementation

Part of the workshop was the distribution of a survey to the participants, after the soil-testing was completed, and a short summary of the survey and its aims verbally communicated to the assembled group. The survey was conducted as an additional method of empirical data collection to understand how participation in the workshop affected the subjective notions of soil and relationship to the urban environment on different levels.

10.2.1 Survey – Population and sampling

Workshop participants were invited voluntarily and anonymously fill in the survey. It was available to them in a printed version and as QR-code immediately after the workshop. To ensure a wider spread of responses, it was also included in the follow-up e-mail for which each participant had signed up for.

The survey was replied by six of the official workshop participants which had scanned the QR-code immediately after the workshop. When subsequently enquiring in the follow-up email for a higher number of participants, no one could be recruited. To the demographic question only one participant indicated itself to be in the age range of 18 to 34 years. The other five were between 35 and 64 years old.

10.2.2 Survey – Design and outcomes

The online tool Google Forms was used to conduct the survey due to its wide availability and comparatively secure data processing. Within responses can be displayed individually, but also in relation to the total number of responses. The final survey-form consisted of a total of eight quantitative questions and related to the thematic content and collective practical activities of the workshop. In addition to the consent form and one demographic question, it contained other thematic questions, such as five Likert scale, one multiple choice, and two open-ended questions. The survey mainly dealt with personal emotions, perceptions, and takeaways (see index B).

First, the five Likert scale replies will be stated in the following. Likert scale was chosen for its ability to convert qualitative perceptions into quantitative data and for its ease of use (Joshi et al., 2015, p. 397). The five response options were “not at all”, “slightly”, “moderately”, “very”, “extremely”.

Half of the participants did rate their awareness of the importance of urban soil for environmental sustainability before taking part in the citizen science soil test as very aware. The youngest participant stated that he had moderately been aware, and the other two participants were just slightly aware.

All people uniformly stated to feel very connected to the urban environment after taking part in the workshop.

For the question if their interest in participating in other environmental activities or initiatives had been increasing after experiencing soil also half of the participants stated that it increased very much, for one it even extremely increased, whilst for one was moderately and another it only slightly increased.

The responses to the question if the soil testing activity had affected their perception of the own role in local environmental activities were very mixed. For one person it didn't change, for another one it moderately changed, for two people it slightly changed and for other two it changed very much.

Half of them felt slightly and one moderately more inclined to talk to friends, family or neighbours about environmental issues after taking this soil test and one very. However, one was very much and another one extremely much more inclined.

The half multiple choice question asked which aspects of the soil test they found most interesting. A total of five times supported the statements that it had been the "direct contact with the soil", and the "cooperation with members of the community". "Understanding scientific methods" was just selected by two people. And only one time "the outdoor experience", and one time "learning about the role of soil in sustainability" had been chosen.

The first of the open questions reflected a very uniform experience where four out of five were referring to the high number of worms when asked about the most valuable insight through their participation. Within one person also specified the connection to good soil quality. Only one

person noted as insight the excitement of urban children when they can learn new things and be guided.

The second open question asked about the potential of urban soil research, and how it could strengthen society for sustainable development in cities. Here responses were more mixed and addressing different contributions, such as “people realise that the soil in the city is sometimes poor and that this has an impact on bees etc.”, “involving children and young people”, “raising awareness” “communal experience and action.”, “increased awareness of the immediate environment.”

10.3 Review by Mei Meidling – Blog entry

Because this study evaluates the effect of CSS on participants, it is therefore appropriate to also mention other feedback that was addressed to the workshop, which will follow below.

About ten days after the realisation of the workshop, Mei Meidling (2024) published a blog entry heading: “That was our OPEN SOIL workshop”. In it, the day with some details was described. In addition, it described and reflected the experience from their perspective. Opening with: “It was really fun for us city people to dig in the earth and learn a lot in the process“, throughout positive, appreciative and encouraging wording was used such as “very impressive”, “impressive difference between the soils”, “a real highlight”, “Splendid!“, to give just some examples. Some short videos, as well as a group picture were used to give an insight about short moments and to reflect the atmosphere. In the end the workshop was valued as impressive” and “exciting”.

Even when this feedback has been produced as a marketing for the Mei Meidling initiative, it anyhow reflects the overall effect the workshop had.

11 Situational Analysis

In the following chapter, the CSS situational analysis procedure is shortly described. Then, the outcomes of the situational analysis, with an explanation of the most important factors, is further laid out on hand of the CSS situational map.

As previously described in the chapter “Implied Methodology: Situational Grounded Analysis” the study refers to Clarke (2005) in conducting a situational analysis and finally generates a situational map.

Therefore, the first step was to create codes and categories for the whole study. After coding guidelines of Strauss (1987) four categories were found throughout the case study analysis. With the situational analysis, mainly the workshop was analysed, themes identified, codes and categories were created. Then the results of oral feedback, the survey, and the blog entry were retrieved for better understanding, and to ensure the correctness of made assumptions. This repeated rechecking was helpful to justify the final codes, or to correct these if needed. The final situational map after Clarke was then generated using the generated codes.

11.1 Situational Analysis - Design and outcomes

For Strauss (1987) it is essential to apply paradigm items of “condition, consequences, strategies and tactics,[and] interaction among the actors” (pp. 43–44), which will be considered throughout the analysis.

The paradigm items of “consequences” are considered in form of integrating the feedback. The “strategies and tactics”, which are part of the workshop and the survey design have already been explained in more detail. Still, it was observed, that in the *opening round* elderly participants were resigned but opened during the whole workshop procedure. Then, the *change of locations* supported that people mingled and interacted with strangers, family structures opened, while they had to interact to coordinate the move. In the subgroups each group concentrated on their internal

findings and different types of soils were collected, which in turn supported the compatibility in the *united sampling*. The *closing round* supported the feeling of sharing the same experience and feeling of togetherness, which was then supported by the survey.

For the paradigm item of “interaction of actors”, involved actors were pointed out separately in chapter “Key stakeholder groups”. Even when OSA and Meidling were essential to conduct the CSS, it must be pointed out, that Mei Meiling and No.14, were a centre piece for the connection and in the overall dynamics. Mei Meidling reached many people through their channels and can be seen a well-established stakeholder in the district. Finally, four key concepts of the interaction based on the CSS could be identified: Excitement or curiosity, engagement, empowerment, and education.

Curiosity and excitement are the first concept that was resulting from coding the CSS. For the group of pedestrians, it can be noted, that they came by, asked and joined because they were curious, and then stayed out of excitement or because they learned something interesting. All participating children shared a high amount of excitement for and curiosity while digging. Here some sense of gamification of the experience can even be noted.

It is important to recognize that the CSS was able to provide a physical place where people of the community could come together and engage (Lafrenière, 2016, p. 116). The sense of community was a factor of excitement reflected in the survey and the blog entry. Furthermore, it was possible to experience this through the close exchange and contact between the people gathered around the holes. Through this experience, they could feel, discover, smell, and even listen to the soils. Equally, the consistently good feedback on the workshop in the survey and the blog entry supports the enthusiasm factor perfectly.

Engagement is another concept that was resulting from coding the CSS. Through innovative alignments for specific problems, and policy mobility for specific niches, adaptation experiments are able for particular climate change challenges (Harriet Bulkeley et al., 2015, p. 62). Throughout the workshop some situations can be allocated to a close engagement of individuals, groups or in the neighbourhood. Even when more than half of the joining participants were already part of neighbourhood initiatives, like *Mei Meidling*, urban gardens, or other sustainability initiatives, the CSS reached some external people, touching their engagement. This might explain the reflected high level of awareness about urban soil importance in advance in the survey. However, these participants were predominantly more inclined to engage themselves.

Besides, it fostered the interconnection internally and between existing groups. With his presentation and the call for action Specifically, No.8 showed a high level of personal engagement. Through interaction and acknowledgement of their natural environment, the residents of Meidling might remain active. This concept addresses the fact that, in addition to targeted policy interventions, policies should include a "supportive governance" framework to facilitate the building of social resilience (Voulvoulis et al., 2022, p. 3).

The third concept that resulted from coding the CSS is *Empowerment*. Through the fact that No.8 could present his outputs to a bigger group of recipients, and then received good feedback for his engagement, in turn supports his sense of empowerment. Also, children were highly involved, considered and treated as experts in their field, thus empowered. Since the children on location A, which were brought in to help gather soil data, were allowed to take over the task of analysing the hole, a level of empowerment can also be assumed here.

Since decisions on effective climate change action is based on political priorities and emerge with specific contexts it is interesting to understand the level of willingness to pressure urban politics through CSS (Harriet Bulkeley et al., 2015, p. 23). Learning the tool and being able

to use the learnings empowers people to take common action and the fact that data has been gathered for open access of society fosters personal responsibility. However, not so many participants of the survey would afterwards bring environmental topics to their private circles, this is still unclear for the group of children, which seemed to have a new experience.

In the sense of environmental ethicists also individual organisms, ecosystems, species, and sentient nonhuman creatures are examples of nonhuman things and locations that have value (Palmer et al., 2014, p. 437). This could throughout be seen in the joy of participants when it came to the count of species, which may indirectly generate empowerment in nature. Children might be more likely to rethink actions, understand the human impact, and direct their path for more environmental ethical action.

Education, as the last concept that was resulting from coding the CSS, is multi-faceted. It touches on direct and indirect education. First it must be acknowledged that the children's high level of soil knowledge might come from a closer connection to soils by playing on the ground and thus they can easily recall their observations. However, through discussing this matter, they might see the bigger value in it. Besides, through providing a bed for the worms, in putting soils back after testing, and by not hurting the surrounding alle children indirectly learned to care for living creatures and other natural species. Besides, applying sky directions was practically for the children at location A.

Some learnings were transmitted through the inputs of the facilitators, their explanations, and the direct knowledge exchange inside of the group. However, the learnings from the introductory round transferred to experienced, lived education through applying them. The survey replies on interest in *direct contact with soils* confirms the enjoyment of the lived experience, while fewer people selected directly *learning about soils*. The soil functions are one example for learning from lived education, such as the water storage function, that was exemplified through

the jar test. Besides, they were proven the history storage function of soils through finding trash and since hole B was discovering the history of the park.

Indirectly participants were learning the understanding of unity, through cooperation and exchange and the thrive for the same goal. For No.14, it was additionally beneficial to understand, that through CSS children can get activated and might apply CSS for reaching out to other generations in the future. Experiencing soils, their observed reactions, and the variety of life in them were sensed leanings, which might support the agency of soils as matter for liveable cities. The young boy, No.6 who had secretly taken soil from another hole, suspected the fertility of dark soil to be better than the sandy sample they were working with. Even when some of the specific participants knew about soils importance in advance, the majority reported of having learned about the unsuspected high quality of urban soils.

11.2 Situational Map

The elaborated situational map of the matter (*Figure 22*) provides an overview of the resulting landscape. Here, the main categories from the case study analysis are shown, together with individual or collective human elements, discursive constructions, political elements, main themes, non-human/silent actors/actants, and other important factors, that are all based on before elaborated data (Clarke, 2012).

Central in lights orange, CSS itself is presented. In strong orange the categories of the case study are exemplified, which stand in close connection to the grey codes, which are showing topics that were touched upon. In brown, silent actants are represented, which are important for the whole CSS intervention. The green factors represent individual, as well as group stakeholders. In contrast to that are standing the light brown, the political actants. Blue factors describe the central frameworks that have been touched upon. The yellow unconnected factors represent the ethics, which are surrounding the whole CSS construct. As the acknowledged aim for CSS is SET, it is presented in red.

CHAPTER IV – RESEARCH EXAMINATION

In this chapter the generated outcomes of the overall study are be examined. This happens trough a discussion about CSS in context of the SET. Then a conclusion finalises the thesis.

12 Citizen Soil Science for the socio-ecological transition

In this section the previously constructed knowledge about CSS are discussed, its strength and limitations elaborated on, and interlinkages with the overall topical context of a SET are retraced. However, results should be inferred with caution since the research is subject to limitations. The limitations and potential improvement of the research design will be reflected on. Future implementation and research potential will give an outlook, while equally closing the chapter. As proclaimed in chapter 4.2 *Implied Methodology: Situational Grounded Analysis*, the final outcome of the study is the situational map, which has been presented in the chapter above. Together with the ground laying literature research and the case study the outcomes are looked at in more detailed. The results show how CSS, as an urban intervention, affects citizens, on the social level by engaging with soils, on the ecological level, and vice versa.

The four categories identified through the situational analysis, “education, excitement and curiosity, empowerment, and engagement” show the many impressions and effects on participants of the case study, the workshop and the survey. Each consists of observations from very different directions. Besides, literature research provides information about elements that stand in close relation with the subject of this research. Topics that support the relevance of urban CSS for the creation of liveable cities are soils as a matter, citizen engagement, and the need for green urban infrastructure. These chapters proved in detail that each of the touching elements has high importance considering the SET. The literature research about EUs and

Vienna's political soils landscape provides insights about its status and gives background information for the case study together with the chapters of Meidling and OSA.

As stated in the soils chapter, this subject has long time not been of high interest but besides of growing interest of the matter in politics, seen in the chapter about the political landscape, and arts, as in recent exhibitions, web pages and books, also CSS, as an experimental intervention, supports curiosity and empowerment of citizens to get active and raise questions regarding soils.

It was shown that soils multiple benefits and functions make them an important lever with the aim to reach liveable cities for flora, fauna and human beings. Therein a healthy soil system supports that micro-organisms work efficiently and that the biochemical storage function, such as carbon, stays intact. This makes life on earth highly dependent on soil, besides of anyhow providing a direct habitat, breeding place, or other dependencies for most species.

However, reasons were presented which explain under which stress the soil system suffer. Surface sealing, heating islands, extraction, bad citizens habits are just few of these. The anthropogenic impact was also observed during the workshop while people found trash and no organic life in the sandy degraded test location. As described in the chapter about ethical premises, environmental ethics would support soils protection for its own sake, contrary to soils extractivism and facing Wolfe's (2002) soil chauvinism. In contrast, with the knowledge of the social and ecosystem benefits of soils for human being calls upon the ethics of care that would take soils as a measure with the aim to care for the community. Whatever ethics, citizens engagement addresses co-responsibility, after Rottenbacher (2005), whereby the interaction of the CSS participants improves their sense for community, which in reverse supports resilient actions.

As elaborating on citizen engagement, it became clear that no matter on which ethics people's actions base, correct behaviour can be supported by knowledge about issues that can arise with the wrong behaviour. Besides, it became evident, that current common soil practices must be questioned and discussed, as well as it needs awareness rising about soils benefits to prevent from "eco-evolutionary consequences", how Philippot et al. (2024) put it. Thus, CSS can be seen as a well-suited intervention which specifically addresses this need in a direct and indirect way. Ryans *Precautionary Ecosystem Health Principle* is equally addressed through this, while being trained about the urban adaptation potential of healthy soils and more green spaces.

In being an experimental intervention the OSA design accepts "good enough" answers which supports an easy accessibility and potentially greater civic collaboration, right after Jackson (2021). However, this doesn't lead to highly scientific data and the case study showed that, even with this open approach, people were looking for guidance in the user manual. Still, as this soil science is experimental, soil can be scientifically experienced outside the laboratory, which has been recognised as one of its advantages.

After all, it is still possible to generate important soil information like compactness, worm count and root fertility in a user-friendly way, by only using a shovel and a mobile phone. This generates greater social engagement and more data for scientists can be generated. And through the inclusive approach, resilient solutions for green urban infrastructure can be found but also reverse, people would understand environmental policy regulations more consciously, as stated before. It can be said that CSS breaks through structural dominance, which was addressed in chapter *The importance of Citizen Engagement*.

About citizen engagement it was stated that municipalities need to engage closely with, and integrate citizens, to have diverse decision-making processes and find adjusted and well received solutions. However, the statement that it needs citizen engagement to do green urbanism is difficult to refer to in the Viennese context because as shown in the chapter about the Viennese

political landscape, the government already does a lot for green design and even provides a soil map. Still, as quantitatively proven in the chapter *Place of conduct: Meidling*, the district itself invests more money into traffic infrastructure than in infrastructure for recreational services. Also, participant No.8 personally emphasized in the closing round of the workshop that it needs citizens alignment to advocate for local needs. Besides, the engagement of Mei Meidling, which was shown to support transdisciplinary exchange and receives good recognition, and the garden from participant No.1, which grew from a guerilla garden and is now officially recognized, show that self-organization from side of the citizens is at stake also in Vienna.

What is interesting to mention is the fact that OSA was born from a lack of possibilities on the municipal level and then received funding from the EU level. This shows how political agendas are often colliding, or just not really addressing direct local needs.

These movements show that common action has an impact and people that are engaging can bring their local needs further in a time efficient way by action instead of resistance. Also, CSS can be seen as a highly time efficient method since it raises people's awareness to take action, educates them about soils and meanwhile collects scientific data. OSA even used the wisdom of the crowds, that Lefebvre (2022) was pointing at, in designing their methods. To repeat an important statement from above Schwarz et al. (2022) said: "people in cities are the advocates, educators, and caretakers that soil systems need".

Considering the SET, CSS supports the idea of shifting it from "artificial nature" to "sustainable nature" by changing citizens current claims about what soils are, to a more conscious how they should be, considering all the above elaborated facts. Also seen in the SET chapter, it needs improved environmental resilience in municipalities and better municipal planning through increased operationalization. Thus, the aim of CSS with the approach to collect soil data through citizens engagement with the people, and for the people, might help to improve

urban planning. Additionally, with the knowledge of participants they can come up with new environmental protection ideas. In this regard it exactly touches upon this point.

To see CSS from the broader perspective, as with Voulvoulis, the SDGs would serve as framework for the SET but in light of the literature review, they lack consensus about operationalization. The situational map either way shows, that the SDG's are an international framework for the SET, but they are not touching the societal understanding of change in that regard. Therefore, it is local economies and societies that must act. CCS moves in more than just one transition focus for sustainable transformation. Being transdisciplinary in its approach, it supports reaching liveable cities (SDG 11) through climate action (SDG 13) and focuses on protecting life on land (SDG 15), and all other organism under the surface.

As before elaborated, the reasons why soils must be protected are various and showing their functioning, services and benefits for the human being, provides ethical reasoning. Also, reasons for engagement are many, as seen in the chapter *The importance of Citizen Engagement*. In Meidling participant were mostly gardeners or already part of an association. However, it was not just the topic of soil, but in general learning about their environment and the common action that motivated people to join and might support the continues care for environment and community.

Through the generated excitement in the workshop, this matter can be made attractive, while equally increasing its importance, and trigger soil-care subversively, especially on children. Here it must be recognized that prior knowledge was given, and that through the workshop format but with the fostered internal exchange knowledge could flow between participants.

After Oliver Lefevres five R's for more urban ecology, all could be observed. „Revolution“ through self-empowerment, „regeneration“ through soil care, and „renovation, reform and „regulation“ in new city planning and legislation.

Thinking CSS in a system can be helpful to understand the landscape in which it is moving, and to consequentially better understand its impact on the SET. However, this research doesn't provide a full picture, but provides one perspective with several points that are touching upon this. Also, the moments between the different stages of the workshop would provide further insight into people's behaviour and could be delved into, in a more comprehensive and longer scientific research, which might equally cover long term effects of CSS.

Which was pointed at here was the social and the ecological layer of urban CSS for liveable cities and the SET. The two science layers of soils and citizens are addressing different areas and could be differentiated and equally more elaborated on in detail.

Long-term effects and individual effects on single participants were not proceeded with. It is not possible to determine exactly from a single implementation whether a liveable city can be achieved through CSS in a real case. Further studies, comparisons and data collection, in sense of test-retest reliability, could give the specific CSS intervention more recognition and validation.

The matter is still a young field, but it has the potential to spark public interest in soil health and enrich academic discussion. For a full understanding, there is a need for more academic examination of the exact theme of CSS. More addressed should be the gap that soil science is often heavily focused on agriculture. Also, it needs more investigation about the societal impacts of CSS on humans.

In summary, Citizen Soil Science offers the chance to democratize soil research, raise soil awareness and neighbourhood engagement, thus make a valuable contribution to a sustainable future.

13 Conclusions

This thesis was addressing the social and ecological level of urban CSSs effects on the SET. Thereby it was analysed how citizens' contact with urban soil strengthens their connection with nature, with one another, and their general engagement with the environment. For the bigger overall context a CSS situational map was worked out based on the methodological framework of Clarke (2005). For this analysis, three methods were applied. First, literature research that delved into the touching elements and provided a thematic assessment. Then two applied methods were applied with a workshop and a survey.

The public soil testing workshop was conducted in Meidling, Vienna, utilizing the OSA methodology and was key for measuring its impact on the citizens. The study yielded valuable insights into the social and ecological experiences of citizens in an urban environment.

The lessons learned from this project are numerous on both citizens and the urban soil itself. CSS helps to empower citizens. Through their participation, citizens gained a deeper understanding of Soil's vital functions and services, fostering a sense of curiosity and responsibility towards its protection. This empowerment extends to questioning environmental policies and advocating for sustainable solutions. Also, the project fostered a sense of community and neighbourhood identification through collaboration and direct contact with the local soil. This shows how CSS enhances engagement. By educating and informing participating, citizens gained knowledge about soil health and its role in a healthy environment, fostering environmentally friendly attitudes and behaviour. This aligns with the principles of SET and care and environmental ethics. This project demonstrates how CSS effectively addresses both aspects. Gathering data and this with, generating valuable soil data is an ecological benefit. The data can be utilized by both citizens and scientists for further research and urban planning initiatives.

Its transdisciplinary approach offers a unique way to bridge the gap between citizens, science, and policy. By fostering trust and empowering citizens, CSS enables them to participate in shaping a sustainable urban environment. Still, there is a need for further exploration of CSS. It requires more academic research in various aspects of CSS to fully understand its potential, support its recognition, and optimise its implementation.

The study exemplifies how CSS can serve as an experimental intervention, paving the way for a more sustainable future. By fostering engagement with the local environment and empowering citizens, it can be a catalyst for positive change in urban planning and environmental consciousness. However, it needs test-retest reliability as continued academic exploration to measure its long-term impact. Ultimately, fostering a deeper understanding of soils through CSS is a crucial step towards achieving a more sustainable future for our cities.

By prioritizing care and investing in understanding nature, we might discover that within the nature-human nexus, nature isn't the one needing protection, but rather the one with the most to offer in return.

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INDEX

A) Facilitation guideline – Opening round

1. **Question (Q):** Who is from the neighbourhood in Meidling?
2. **Q:** Did you ever dig into your urban soil?
3. **Q:** Have you ever participated in citizen science and can explain what it is?
4. **Input (I):**
 - a. Citizen Science: Often divided academia and society, citizen science brings it together; Science is limited, citizens are closer to the fields. Exchange sensemaking; In SC often citizens are working under scientists; OSA is bottom up by citizens.
 - b. OSA: History of OSA; Right to the city; Lack of urban green spaces; Engagement for environment
 - c. Social and ecological ideas: Mapping empowerment tool; Access to everyone; Neighbourhood engagement.
5. **Q:** Why is soil important? Can you name some functions of soil?
6. **I:**
 - a. Soil benefits: As a living habitat for plants and animals; Soil functions; Edible city approaches; Water storage function & sponge city concept; Foundation for construction; Showing visual material about soil life.
 - b. Urban soil issues: Heating Island effect: Problem for vulnerable groups, animals, and the organisms in the soil; Biodiversity loss; Sealing: Loss of all soil functions; Loss of soil quality; Erosion; Pollution; Toxins; Overuse.
7. **Q:** What do you think you will discover?

B) Survey questions**Question 1**

How would you rate your awareness of the importance of urban soil for environmental sustainability before taking part in the citizen science soil test?

Question 2

How connected do you feel to the urban environment after taking part in the soil test?

Question 3

Has this experience with the soil increased your interest in participating in other environmental activities or initiatives?

Question 4

Select all that apply: Which aspects of the soil test did you find most interesting?

Question 5

How has this activity with the soil affected your perception of your role in local environmental activities?

Question 6

After taking this soil test, do you feel more inclined to talk to friends, family or neighbours about environmental issues?

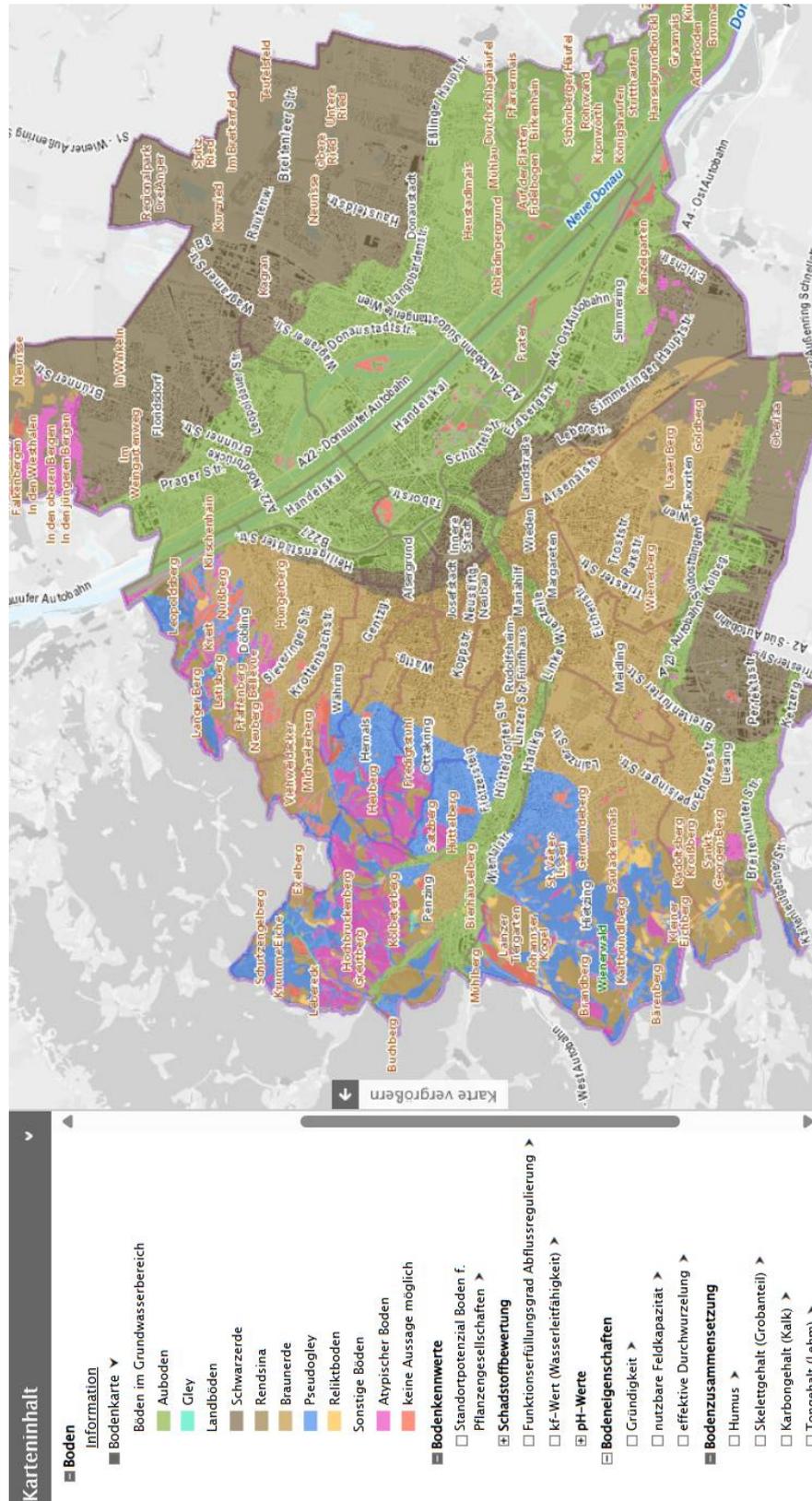
Question 7

What was the most valuable insight you gained from participating in the citizen science soil test?

Question 8

In your opinion, how can research into urban soil contribute to strengthening society for sustainable development in cities?

C) Screenshot of legend and environmental map of Vienna depicting soil values.



(Stadt Wien. Wien Umweltgut, n.d.)