**Czech University of Life Sciences Prague**

**Faculty of Environmental Sciences**

**Department of**
**Landscape and Urban Planning (FES)**

# Master's Thesis

## Reframing Approaches To Green Infrastructure Interventions In Urban Environments And Exploring Planning Using Agent-Based Models.

**Bc Arch. Rafia Masud**

# CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Environmental Sciences

# DIPLOMA THESIS ASSIGNMENT

Bc. arch. Rafia Masud

Landscape Engineering
Landscape Planning

Thesis title

**Reframing Approaches to green infrastructure interventions in urban environments and exploring planning using agent-based models.**

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**Objectives of thesis**

The aim of this thesis will be to test the various interconnected ideas explored in literature.
Problem-identification and visions: Reframing the issue of green infrastructure interventions in urban environments based on stakeholder perceptions and ecological goals. Exploring if synergy can be found between ecological and socio-economic values.
Time and scale-based green infrastructure planning: Explore rules that can govern optimum green infrastructure planning in dense urban environments and represent them in dynamic models that react to evolving urban conditions.

**Methodology**

Part 1: By utilizing user survey and literature pertaining to the properties of complex and challenging problems, incorrect problem identification methodologies, the emergence of frameworks designed to combat these approaches, and visioning for desired futures, a practical framework will be developed that addresses the problem identification aspects associated with planning for green infrastructure on appropriate scales.

Part II: Using Cellular Automata configuration in GIS environments and other graphic representation programs to define rules that can govern model iterations through time and space and predict green infrastructure evolution in a dynamic urban environment.

**The proposed extent of the thesis**

65

**Keywords**

Urbanism, green infrastructure, agent-based modeling, possible futures, urban interventions

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**Recommended information sources**

Hillier, B. (2015). Chapter: Non discursive techniques. In Space is the machine: A configurational theory of architecture. essay, Space Syntax

Irwin, Terry. (2018). The Emerging Transition Design Approach

Roggema, R. (2013). Towards a spatial planning framework for climate adaptation. Swarm Planning.

Tonkinwise, C. (2015). Design for transitions from and to what? Design Philosophy Papers, 13(1), 85–92

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Electronic approval: 14. 3. 2023

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Dean

Prague on 17. 03. 2023

## Declaration

I hereby declare that I have independently elaborated the diploma thesis with the topic "*Reframing Approaches To Green Infrastructure Interventions In Urban Environments And Exploring Planning Using Agent-Based Models*" and that I have cited all the information sources that I used in the thesis and that are also listed at the end of the thesis in the list of used information sources. I am aware that my diploma/final thesis is subject to Act No. 121/2000 Coll., On copyright, on rights related to copyright and on amendment of some acts, as amended by later regulations, particularly the provisions of Section 35(3) of the act on the use of the thesis. I am aware that by submitting the diploma/final thesis I agree with its publication under Act No. 111/1998 Coll., on universities and on the change and amendments of some acts, as amended, regardless of the result of its defense. With my own signature, I also declare that the electronic version is identical to the printed version and the data stated in the thesis has been processed in relation to the GDPR.

**Praha 17 March 2023 Rafia Masud**

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**Praha 17 March 2023 Rafia Masud**

**Reframing Approaches To Green Infrastructure Interventions In Urban Environments And Exploring Planning Using Agent-Based Models.**


## Abstract

This thesis focuses on understanding the complex nature of urban environments and the need for collective action to bring about positive change in sustainable urban design. The author argues that problem identification and proposed solutions must involve rigorous sharing and refining of knowledge gathered from multiple perspectives. The thesis proposes a methodology for designing systems that match the dynamic nature of ecological problems and describes how the language used to describe these complex systems must be carefully framed to avoid reducing human values to mere metrics. The thesis explores the idea of transition design and the need to align problem statements and proposed solutions with larger movements seeking to achieve similar goals. The thesis presents a case study of the revitalization of historical neighborhoods in Prague and demonstrates how smart tools and data visualization can be used to inform urban design decisions. The resulting models show patterns of interest, strong correlations, and complete randomness that could inspire new explorations in sustainable urban design.



## Keywords

Urbanism, green infrastructure, agent-based modeling, possible futures, urban interventions

**Přeformulování přístupů k zásahům do zelené infrastruktury v městském prostředí a zkoumání plánování pomocí modelů založených na agentech.**


## Abstraktní

Tato práce se zaměřuje na pochopení komplexní povahy městského prostředí a potřeby kolektivní akce k dosažení pozitivní změny v udržitelném městském designu. Autor tvrdí, že identifikace problémů a navrhovaná řešení musí zahrnovat důsledné sdílení a zpřesňování znalostí shromážděných z různých úhlů pohledu. Práce navrhuje metodologii pro navrhování systémů, které odpovídají dynamické povaze ekologických problémů, a popisuje, jak musí být jazyk používaný k popisu těchto komplexních systémů pečlivě koncipován, aby se zabránilo redukování lidských hodnot na pouhé metriky. Práce zkoumá myšlenku přechodového designu a potřebu sladit problémová prohlášení a navrhovaná řešení s většími hnutími usilujícími o dosažení podobných cílů. Práce představuje případovou studii revitalizace historických čtvrtí v Praze a demonstruje, jak lze využít chytré nástroje a vizualizaci dat při rozhodování o urbanismu. Výsledné modely ukazují vzorce zájmu, silné korelace a úplnou náhodnost, které by mohly inspirovat nové výzkumy v oblasti udržitelného městského designu.



## Klíčová slova

Urbanismus, zelená infrastruktura, modelování založené na agentech, možná budoucnost, městské intervence

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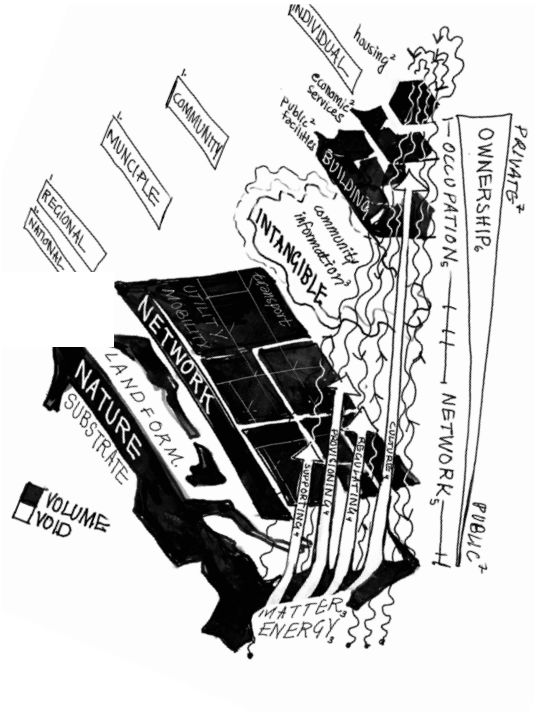
# Introduction
## Visualizing Complexity

Because everything in our visible world is so intricately connected, only an ever-evolving, dynamic model can truly represent it. This confounding complexity is, however, also an opportunity. Exploring this complexity often leads to interesting discoveries. **As one places certain elements, ideas, or artifacts at the center,** other objects can instinctively organize around them, and **even hidden connections can emerge.** By connecting upwards and downwards, by cause and effect, a single unit embedded within its discernible layer creates a chain of links between all of these blending parts. This way of looking at complexity can not only help to gain a better understanding of the interconnectedness of our world but also offers the potential for creating useful new solutions (Drake et al., 2007).




(fig-1)A composite sketch of The urbanism layers organized around the intangible, adapted from common existing models: from substrate to built environment. Based on commonly used land elements,the organization scale, ownership scale, solid and voids, intangible elements, movement of matter and energy, mainly as ecosystem services, built environment functions (author).

One definition of Spatial planning is that it is the process of organizing the use and development of this visible – often built world – in a specific area. It involves the management of physical, social, economic, and environmental factors to create sustainable and livable communities (Yoshida et al.,2020). The goal of spatial planning is to understand the complex interactions between human activity and the natural environment and to use this understanding to guide the development of cities, towns, and rural areas in a way that promotes social, economic, and environmental well-being. It is a way to understand how the world around us is used and how it can be used in the future. Spatial planning has the potential to create better, more resilient communities.

Spatial planning often relies on manipulating this multidimensional physical environment to alter the presence and movement of matter, energy, and even the more intangible components such as information (Lopez 2016). By doing this, spatial planning is able to create an interconnected and interdependent web that can expand outwards toward more complex operations. These more complex operations can be used to provide more resilient environments that can better

protect against various threats, such as climate change, natural disasters, and other environmental issues.

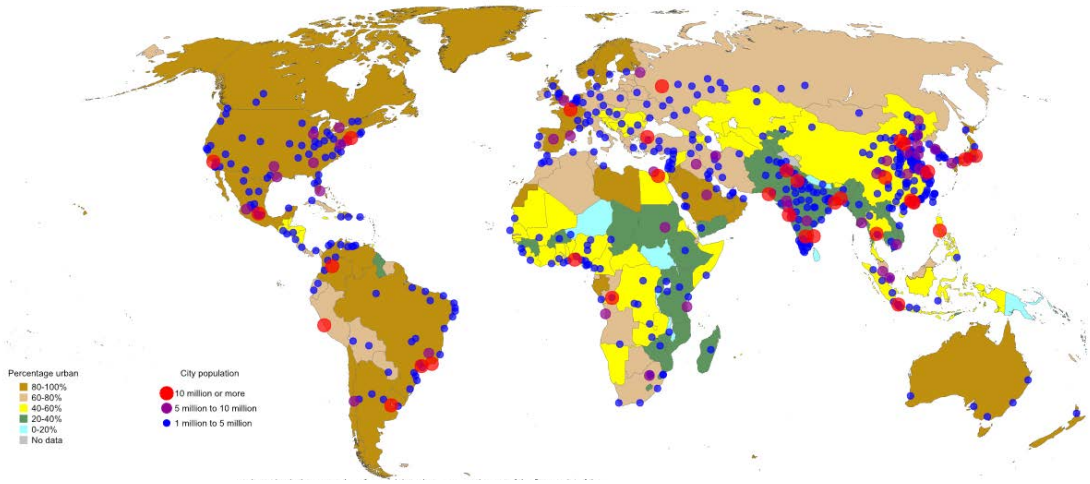
## 1.Literature Review

### 1.1 Spatial Planning Practices and Problem Identification

*1.1.1: Extreme Climate Events*

Extreme climate events are happening more frequently and with greater intensity due to human-caused actions that predicate climate change. Additionally, human activities such as deforestation, urbanization, and land-use change can affect the local and regional climates and exacerbate the risks associated with extreme weather events. When these events occur, they will undoubtedly cause devastation, but they will also leave clues for those who are willing to investigate. The component that failed and the policy that was a bad decision will reveal the vulnerability of our systems. Despite complete helplessness in the face of devastation, life manages to recover because human-made systems have, albeit imperfectly, evolved into organisms that readjust and heal – they are resilient.. Although the world is not entirely lost, each time a new wave of catastrophe strikes, the clock is reset for the next. It is reasonable to consider what actions might have been taken to lessen or completely avoid these extreme events. However, as things stand, the causes and motivators of these changes have over time become ingrained in our systems (Roggema, 2020), becoming essentially invisible and seemingly unstoppable.

A strategy in which we retrace our steps, all the way back to the beginning of practices that have become all too familiar to us, and forge a new path from that starting point, informed by the choices




(fig-2) Urbanization estimate (UN.org, 2018) 2019

we have made previously. This strategy of revisiting the root cause and taking corrective action may be our best chance at preventing future catastrophes from happening.

Intensely human-altered environments, despite now forming a considerable percentage of the earth's surface, are very slowly being integrated into the ecological typologies discourse (Keith et al., 2022).

However, for the sake of simplicity, human influence is often treated as no more than an indicator, categorizing ecosystems based on the degree of modification. However, the interplay between human-modified landscapes and the general ecology of a region is complex, and it is wrong to ignore or oversimplify that relationship. The commonly understood ecosystem services tend to be thought of as external processes that interact with human-made environments for their benefits. Humans and their settlements are viewed as a separate system that consumes resources managed by the natural world's more natural biotic and abiotic components. However, there is a growing consensus that the traditional boundaries between human-made and natural ecosystems are too rigid and static to account for their complexity, and this separation is becoming increasingly harmful maintaining for long-term sustainability.

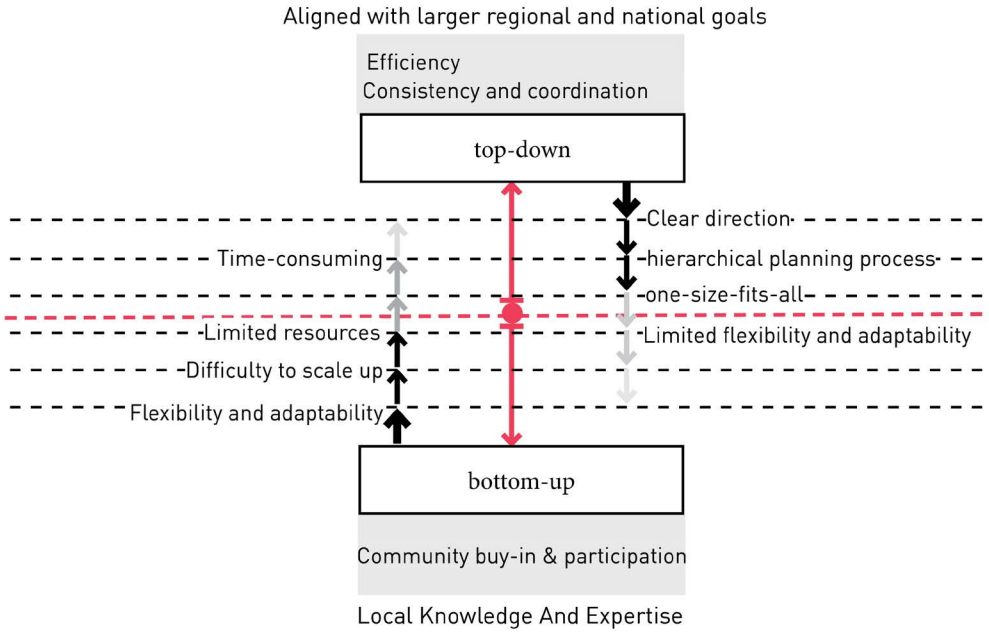
The anthropomorphic ecosystem may have the potential, if not the tendency, to mimic or even become the continuity of the efficiency, complexity, adaptability, and diversity of the natural world from which it evolved (Kelly 2011).

It is possible that technology is not inherently flawed but has simply not reached its full potential or function (Kelly, 2011), and we might only arrive at the true conclusion after taking a certain number of steps and making mistakes.

### *1.1.2 Spatial Planning approaches*

The design of settlements is closely connected to how they are observed. This truth has become self-evident in the late twentieth century because cities were humanity's largest and most complex creations. Experience has taught us about the dangers and consequences of insensitive interventions. However, gaining knowledge in this field is a slow process that relies heavily on trial and error. This, combined with the slow pace of our efforts and even slower pace of our understanding, makes maintaining a continuous cycle of experience and study difficult. Ultimately, this makes gaining a deeper, more theoretical understanding of cities over time difficult (Hillier 2015). However, systematic approaches have been developed, often linear and based on achieving a standard, to ease the decision-making process with varying results.

In spatial planning, there are two main approaches: bottom-up and top-down (Pissourios, 2014).




(fig-3) Any process or practice can fall somewhere along the spectrum of the two working frameworks; as it moves toward the 'smaller scale', it becomes more specialized and is highly attuned to its specific conditions, but lack of resources and inherent specificity can prevent it from replicating on a larger scale; meanwhile, on the 'higher scales', practices and policies are more measurable, the actors are more defined and controlled, but the rigidity and lack of flexibility make it likely unfit to deal with dynamic issues (pissourios, 2014, author)

The bottom-up approach is characterized by a focus on community-based planning and participation. It emphasizes the active involvement of citizens, stakeholders, and community groups in the planning process. This approach is based on the idea that people who live and work in a particular area have the best understanding of the local issues and opportunities, and should therefore play a key role in shaping the future of that area. The bottom-up approach also often involves collaboration between different levels of government, such as local, regional, and national authorities, as well as private sector and non-governmental organizations (Pissourios, 2014).

On the other hand, the top-down approach is characterized by a focus on centralized planning and decision-making. It is based on the idea that experts and government officials have the best understanding of the overall goals and objectives for a particular area, and should therefore play the primary role in shaping its future. This approach often relies on a hierarchical planning process, in which decisions are made by a small group of experts or government officials, and then imposed on the community. (Pissourios, 2014)

Both approaches have their advantages and disadvantages. The bottom-up approach can lead to more community buy-in and support for the plan, but it can also be more time-consuming and may not always align with larger regional or

national goals. The top-down approach can be more efficient and ensure consistency with regional and national goals, but it can also lead to less community buy-in and support and can be less responsive to local needs and conditions.

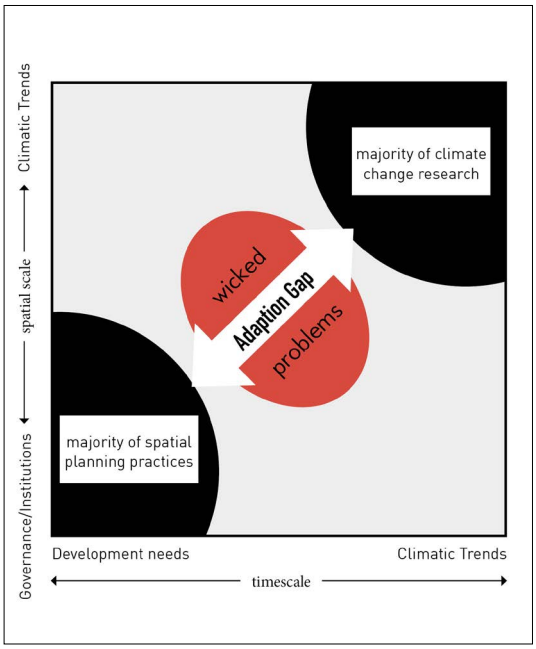
Top-down approaches often rely on a centralized and rigid planning process, in which plans are developed and implemented according to a specific set of goals and objectives. This can make it difficult to adapt to changing ecological conditions and to respond to unexpected ecological events, such as natural disasters or invasive species.

In the context of ecological resilience, the bottom-up approach lacks holistic thinking, reducing problems to isolated incidences, **leading to short-term solutions or simply temporary relief.** Most often, the bottom-up approach fails to consider the higher level variables or ecological drivers, failing to remedy the condition or, better yet, being unable to explore the ability for it to self-organize against problems our settlements may be predicted to face.

In practice, many spatial planning projects use a combination of both approaches, depending on the specific context and goals of the project; however, given the timescales with which we are dealing, certain practices may have long-term effects or reversibly, intense interventions that amount to nothing, and the time to consider approaches that instill a system with a certain level of intelligent self-organizing properties. A local-to-global phenomenon that is an evolution of architectural and urban systems from their basic building blocks, which express human cognition and structure an immediate spatial reality, to the ramified complexity of large-scale systems (Hillier, 1997). This can be seen as the "emergence" of a large-scale organization from small and localized actions, which can lead to a dynamic and adaptive environment that is better suited to address today's complex urban contexts.

*1.1.3: Simple, complicated, complex and wicked : The Adaption Gap*

The "adaptation gap," a term simple enough to visualize, is our way of expressing the complexity and uncertainty that stands between what we can control, our actions, resources, our goals and the future we envision.

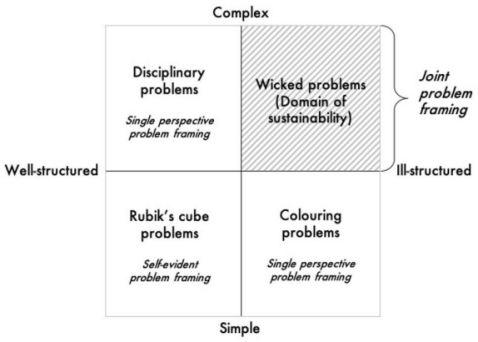



(fig-4) The adaption gap (Roggema 2020).

The root of this 'gap' is the uncertainty that manifests as the perplexing "wicked problems". The term "wicked problem" was coined by design theorists Horst Rittel and Melvin Webber in 1973 to describe the difficulties of tackling issues related to policy-making and planning.

A 'problem' exists when a current reality differs from a desired state (DeYoung et al. 2008; Newell and Simon 1972). Problems can be categorized according to their complexity and understanding of their "structured-ness" (Jonassen and Hung 2008; Jonassen 2000).

Complex and ill-structured, wicked problems are problems affecting a diverse and large number of people (Kønig et al. 2017, Schneider and Buser 2017, Stindt et al. 2016).




(fig-5)Typology of problems. (Jonassen and Hung 2008).

Unlike simple and structured problems (example: mathematics), wicked problems lack clear objectives and have no ending solutions. Moreover, these challenges are subject to real-world constraints that prevent multiple and risk-free attempts at solving.

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|---|---|
| **Complexity** | Wicked problems are made up of many interrelated components, and it is difficult to understand the full scope and impact of the problem. |
| **Interconnectedness** | Wicked problems are often interconnected and interdependent with other problems and systems, making it difficult to isolate and address them in isolation. |
| **Uncertainty** | Wicked problems are often uncertain and difficult to predict, making it challenging to identify cause and effect relationships and to develop effective solutions. |
| **Value-laden:** | Wicked problems are often value-laden, meaning that different stakeholders may have different perspectives and priorities, and may disagree on what constitutes a "good" or "bad" outcome. |

(table-1) key concepts that define the complexity of wicked problems (ref 1997).

The term 'Wicked' has roots in two concepts: (1) that every solution to a problem will be approved by some stakeholders while being rejected by others; and (2) that every definition or framing of a problem also defines the possible solutions (Pohl, 2022). **This is why, when defining or framing a problem, stakeholders' interests already matter.** Structured problems are the opposite of wicked problems. These are problems that are defined and solved in a specific context, such as a game of chess, the solution might be difficult but the rules for all stakeholders stay the same (Pohle 2022).

Examples of wicked problems in spatial planning include climate change, urbanization, and social inequality. These problems are often characterized by their complexity and multi-faceted nature, which makes them difficult to define, understand, and solve. Addressing wicked problems requires a collaborative and adaptive approach that involves engaging diverse stakeholders, considering multiple perspectives, and experimenting with innovative solutions.

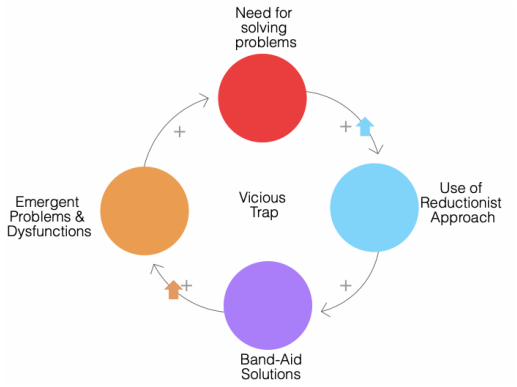
*1.1.4 Frameworks: Problem Framing*

Addressing a wicked problem without acknowledging the necessity for adaptation and innovation beyond the current development requirements and institutional governance system is comparable to searching for a static solution in a dynamic scenario or pursuing linearity in a non-linear environment. Technical-rational methods are inadequate to resolve wicked problems, as these issues are unstructured and complex. **Even if the existing framework is modified to address substantially distinct problems, it will persist in addressing problems in the same manner.** (Roggema, 2020)

The term "complex" also refers to the unpredictable behavior of systems. When the factors interact with one another, the outcome of the situation becomes unpredictable, rarely resembling even the dimensions of the elements from which it emerged. These system properties are referred to as "emergent" because they cannot be predicted by the properties of the individual factors but only by their interaction. (Drake et al., 2007).

Policymakers often avoid acknowledging that problems are unstructured and prefer to focus on incremental changes from the prior issue, implying that they disregard pertinent aspects of the problem and use linear trend extrapolations. (Assuming that existing trends will persist, or a current method will remain applicable.) (Roggema, 2020).

In spatial planning, such a reductionist approach may involve breaking down a complex urban area or region into smaller components such as land use, transportation, housing, and infrastructure, and studying each component separately in order to understand how they contribute to the overall functioning of the area.




(fig-6)band-aid solutions (Psychlife, 2021).

While reductionist approaches can provide useful insights into the functioning of a system, they have limitations. Which is why despite major policy action, the global environmental quality has continued to decline (UN Environment 2019).

They may miss important interactions and feedbacks between different components of the system which may lead to a lack of understanding of the system as a whole and oversimplification of the problems. They also may not take into account the context-specificity of the area, and the complexity and uncertainty of the system's behavior. Continuing to plan, make policy, and negotiate solutions within the existing set of institutional rules and habits complicates planning for an uncertain future (Roggema, 2020).

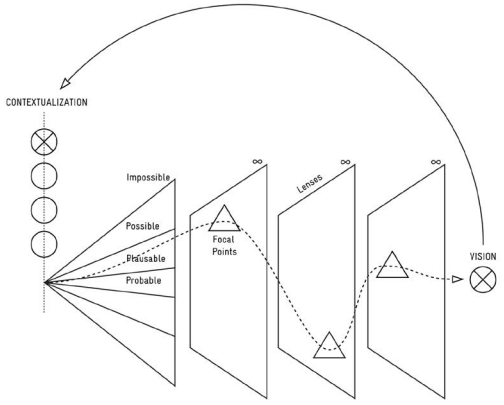
In an effort to engage with the complexity and diversity, scholars have identified problem framing as an important element of trans-disciplinary research (Hirsch Hadorn et al. 2006; Pohl and Hirsch Hadorn 2007; Rossini 2009). A review of environmental policies across diverse sources by Howes et al. (2017). The study found that unclear policy goals, vague terms, insufficient guidance on how to achieve objectives, conflicting objectives, and inadequate communication regarding objectives are major reasons for failed environmental action.

| | |
|---|---|
| **Solving the wrong problem** | Implementation of standards for wastewater treatment to improve quality of water, while most buildings are not yet even connected to wastewater treatment infrastructure |
| **Stating a problem too generally** | A mayor's goal to "improve the well-being of citizens", with no explanation of how to define "well-being". |
| **Stating a problem that cannot solved** | Halting economic growth to prevent carbon emissions |
| **Prematurely focusing on the solution before the problem has been accurately identified** | To build centralized wastewater treatment plants in developing countries to decrease incidents of waterborne diseases, despite the lack of local technical training available that would allow the system to be managed sustainability. |

(table-2)Hardwell (1991) and Clark and Stankey (2006) characterization of inadequate problem framing with examples (Binbin, Ejderyan, 2019)

Additionally, a failure to recognize the interconnectivity of problems can result in inadequate or inaccurate problem framing (Dörner 1996). Thus problem framing is an essential step in addressing complex issues, and it is equally important to identify the right problems to solve. This is especially true in urban environments, where multiple interconnected systems and stakeholders make it challenging to determine the root causes of issues.

Identifying the right problems requires a deep understanding of the context, including the physical, social, economic, and political dimensions of a place. By doing so, we can avoid tackling symptoms




(Fig-7) There is no future, only the futures of futures – by The Extrapolation Factory (Elliot Montgomery & Chris Woebken)

and instead address the underlying causes of problems, leading to more effective and sustainable solutions.

We can explore the concept of problem identification in the context of urban environments and discuss some of the key considerations for this crucial step in the problem-solving process.

Among the developing knowledge-base, several important frameworks have been developed and among them, there are three interesting approaches that offer a holistic outlook to sustainability issues and complexity (Radeljak 2023).

Tonkinwise, and Peter Scupelli at Carnegie Mellon University's School of Design in Pittsburgh, Pennsylvania, in the mid-2010s. They first introduced the concept in a paper titled "Transition Design: A Proposal for a New Area of Design Practice, Study, and Research" published in 2015. Since then, they have further developed the concept through research, teaching, and publications.

The transition design framework will thus be utilized. The central premise of this thesis is to uncover the latent potential within urban elements. By examining the complex and dynamic nature of change

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| **The Driver-Pressure-State-Impact-Response (DPSIR)** (Kristensen, 2004) | Links driving forces, pressures, states, impacts, and political responses to understand the causal relationships and impacts of sustainability issues. It can be applied to any sustainability issue, but creating a DPSIR framework is a complex task as cause-effect relationships need to be carefully described, and environmental changes are rarely attributed to a single cause. The framework helps to visualize natural phenomena and interconnections in a desegregated way. |
| **Resilience Thinking** (Stockholm Resilience, 2019) | A framework for understanding how social and ecological systems cope with change and uncertainty. It recognizes that these systems are complex and interconnected, and aims to build their capacity to adapt and transform in response to disturbances. The framework is based on seven principles, which include maintaining diversity and redundancy, managing connectivity, and promoting continuous learning and broad participation. Polycentric governance is also emphasized as a means of promoting flexible solutions for self-organization. However, the implementation of these principles can be challenging and may require trade-off negotiations between diverse users of ecosystem services. |
| **Transition Design** (Irwin, 2018) | Focuses on catalyzing system-level change, addressing the interdependent relationships between living systems, socio-technical systems, and wicked problems (system problems). It emphasizes stakeholder participation in mapping problems, developing long-term future scenarios, and thinking in terms of "systems interventions" rather than one-off solutions. Transition design advocates for changes in lifestyle as a fundamental context for implementing solutions and uses a process called "backcasting" to continuously monitor and adjust interventions. |

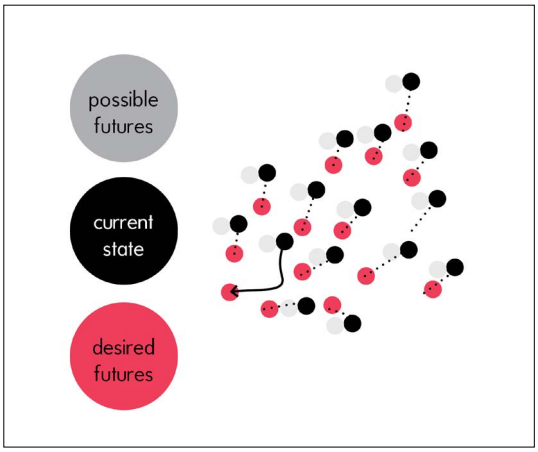
(table-3) Frameworks that offer a holistic approach to sustainability issues and complexity (Radeljak 2023).

For urban intervention initiatives, **transition Design** offers a solution to the dilemma of "one-off interventions" and "band-aid" solutions. The concept of Transition Design was developed by Terry Irwin, Gideon Kossoff, Cameron

in the universe and our urban systems, it becomes clear that conventional approaches to planning often lack a long-term perspective and fall short in considering the cumulative impact of one-off solutions. However, by embracing

the idea that change is inevitable, we can identify the emergent properties and steer the growth of a city towards a desired trajectory.

## 1.2 Desired Futures and Trajectories




(fig-8) (author) Transition Design argues that the societal transitions we are currently in, are heading toward futures we don't necessarily want. But, it also contends that we can intentionally shift our transition trajectories toward futures we do want (Carnegie Mellon University 2023).

### *1.2.1 Emergent Possibilities*

Human societies are in a perpetual state of change, but these changes have been mostly unintentional, leading to unexpected consequences that we only realize in hindsight -which is the history. Transition Design argues that the current societal changes are leading towards undesirable futures, but we have the ability to alter the course of these changes towards the desired outcomes (Tonkinwise et al. 2018).

The current paradigm in which change is viewed as something that can be "managed" through centralized, top-down design processes that produce clear, predictable outcomes is mechanistic and dominant. This linear, cause-and-effect thinking has influenced the design and development of societal infrastructures and policies in the developed world, which has contributed to the global wicked problems mentioned earlier. However, a new trans-disciplinary body of knowledge related to the dynamics of change within complex systems is emerging, especially from chaos and complexity theories. This emerging knowledge challenges the assumptions of the dominant paradigm and has the potential to inform new approaches to design and problem-solving (Tonkinwise et al. 2018).

### *1.2.2 Visioning and backcasting*

Transition Design argues that entire societies (as well as institutions and communities) must intentionally transition toward more sustainable, equitable and desirable long-term futures and, **that these co-created visions (created by the stakeholders) must inform solutions in the present** (Tonkinwise et al. 2018)

*Reframing:* Scenario development, future-casting, and speculative design are methods used to imagine potential future scenarios. These techniques can be used to generate innovative solutions that go beyond current unsustainable social, economic, and political frameworks which often hinder the creation of new and creative solutions. (Irwin 2018)

| | |
|---|---|
| **Reframing: The Present and Future** | Stakeholders "reframe" the problem in the present and envision a long-term future in which it has been resolved. |
| **Mid-term Visions** | Tangible goals that near-term projects can steer towards |
| **Long-term visions** | Open-ended and speculative. Future visions must continually change and evolve and be informed by knowledge gained from projects and initiatives in the present. |

(table-4)(Irwin, 2018) "milestones" in the iterative transition design path.

*Mid-term visions:* Transition Design is a methodology that involves an ongoing and iterative process of envisioning a desirable future, identifying specific actions that can be taken in the present to work towards that future, and continually updating the long-term vision based on what is learned from the outcomes of short-term projects. The short-term tangible visions and interventions help measure and observe action and effects of ongoing interventions. (Irwin 2018).

*Long-term visions:* Transition Design aims to use a variety of foresight techniques to involve stakeholders in co-creating appealing, long-term visions of the future. These visions should address the fears and concerns of different stakeholders while fulfilling their hopes and desires. By doing so, stakeholders can move beyond current differences and work together to achieve desirable futures. These visions can act as a magnet to pull communities towards a shared vision and as a compass to guide the design of systems interventions in the present. The intersection of foresight studies and design has given rise to several new areas of theory, research, and practice that seek to envision and prototype both possible and preferable futures. These areas include Design Fiction (Lindley & Coulton, 2016; Sterling, 2005), Speculative/ Critical Design (Dunne & Raby, 2013), and Experiential Futures (Candy & Dunagan, 2017; Candy & Kornet, (2017). Experiential Futures aim to engage individuals and groups by providing glimpses of a future that resonates more deeply with them than other modalities. According to

| | |
|---|---|
| **Design Fiction** (Lindley & Coulton, 2016; Sterling, 2005) | Imaginative approach to design that involves creating fictional scenarios and objects that depict a possible future. It is a form of speculative design that uses storytelling and visualization techniques to explore the potential consequences of new technologies, products, or systems. Design fiction does not aim to predict the future, but rather to provoke and inspire discussions and debates about possible futures. |
| **Speculative/Critical Design** (Dunne & Raby, 2013) | Challenges the traditional methods of design. Rather than simply reproducing existing perceptions of products and services, SCD aims to transform them, with the aim of initiating public discourse on what constitutes a desirable societal development. |
| **Experiential Futures** (Candy & Dunagan, 2017; Candy & Kornet, 2017) | Creative approach to exploring the future that involves using a range of sensory and experiential techniques to provide individuals and groups with immersive and engaging experiences of possible future scenarios. It is a form of foresight that seeks to generate deep emotional and psychological responses to alternative futures, and to enable participants to reflect on their own values, beliefs, and aspirations. Experiential futures can include a range of methods, such as scenario-based role-play, immersive installations, and participatory storytelling, and they can be used in a variety of contexts, such as policy-making, organizational strategy, and community engagement. |

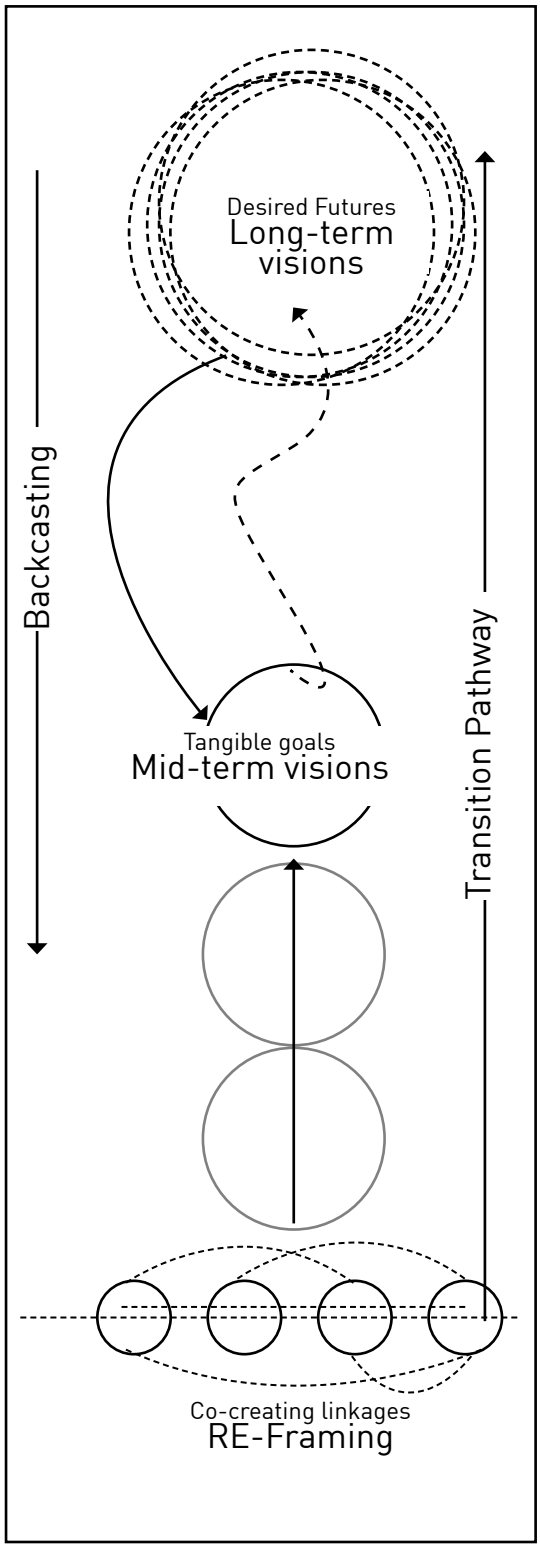
(table-5)Emerging Theories of visions (Irwin. 2018)

Candy and Dunagan, experiential futures can catalyze high-quality engagement, insight, and action to shape change using whatever means fits the situation (Irwin 2018).

*Backcasting* :Opposite of forecasting (which involves predicting future scenarios based on historical data and current trends) 'backcasting' involves starting with a preferred or ideal future and working backwards to identify the steps required to achieve that future. In other words, it involves identifying the key events and data points that would lead to the desired future. This approach is useful in Transition Design because it allows stakeholders to consider the actions, policies, and programs needed today to connect the future to the present. Backcasting is a powerful tool for developing sustainable, resilient, and just systems because it encourages a focus on the long-term vision and the steps needed to achieve it. (Global Centre for Public Service Excellence, 2018).

*1.2.3 Scalability and timescales*

According to transition design, three types of systems exist: living systems, socio-technical systems, and wicked problems, (which are considered as system problems.) Transition designers are mainly concerned with how to initiate and promote system-level change, which may take years to understand and implement effectively. All of these systems operate at various levels of scale, are interconnected,



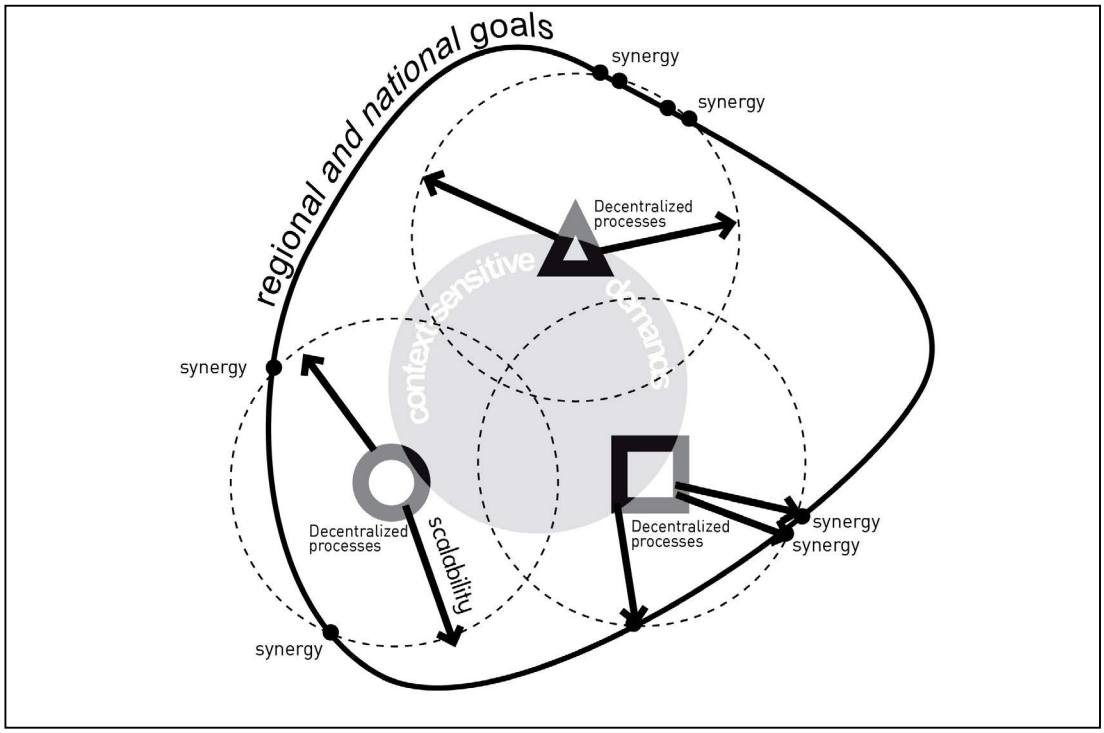

(fig-9)(author) "milestones" in the iterative transition design path. (Adapted from Irwin 2018)

and have feedback loops that generate unexpected outcomes throughout the system, known as the "butterfly effect." Transition design emphasizes the importance of stakeholder participation

in identifying wicked problems to build consensus and implement effective change. It also focuses on developing long-term future scenarios to chart the course of change and encourages thinking in terms of "systems interventions" rather than one-off solutions. Transition designers believe that lifestyle changes are essential to implementing solutions, and that systems-level change is trans-disciplinary by nature. They suggest that "system-level" change should be implemented in three phases: re-framing the present and future, designing interventions, and waiting and observing, that is by backcasting (Tokinwise Et Al 2022).

Based on these ideas, two essential characteristics of emergent planning can be inferred, i.e., scalability and timescales. It is simply not enough to solve the problem for immediate and visible change, interventions need to stand the test of time and be able withstand predictable changes in the system. In practice, this could mean:

*For scalability:* That interventions can be embedded into to the workings of the larger complex systems keeping in mind that they still retain their dynamic 'localized' characteristics and are replicated to on larger scales to act as redundant components. The principles of redundancy refers to the ability of interventions to be duplicated or replicated within a larger system without compromising their effectiveness. It is essential to ensure that interventions can be scaled up to work in more

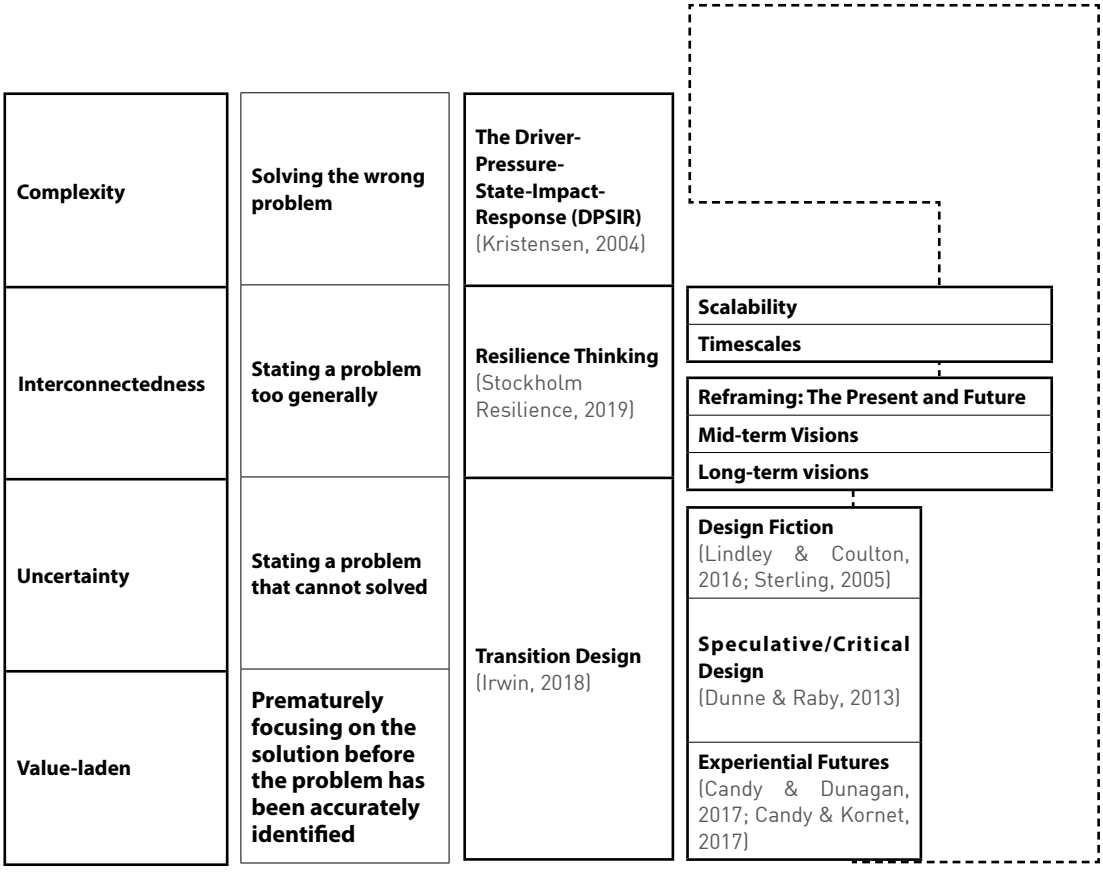



(fig-10) (Author)The scalability of decentralized planning processes determines their long-term impact on regional goals while also benefiting local communities. It is reasonable to believe that aligning with local demands increases adaptation rates, ensures that these practices can be sustained, has allocated resources when the impacts can be measured, has ownership, and is supported by communities. Through scalability, decentralized planning processes are able to extend their positive effects beyond the immediate local level.

significant and more complex systems while still maintaining their dynamic and localized characteristics. The principle of redundancy ensures that the system remains robust and resilient even in the face of disruptions or failures in specific components. (Simonson 2015.)

*Timescales*: In the context of planning interventions, timescales refer to the duration and sequencing of activities involved in implementing a particular intervention. This involves considering both short-term and long-term impacts of the intervention, and how these impacts may unfold over time. Effective planning of timescales involves identifying key milestones and deadlines, as well as anticipating potential challenges and risks that may affect the successful implementation of the intervention. It is important to take a holistic and adaptive approach to timescales, allowing for flexibility and adjustment as new information becomes available or circumstances change. This can help ensure that interventions remain relevant and effective over time.

Based on the interconnected concepts described so far, a workflow can be extracted to inform a spatial design concept.




(fig-11) Project Framework: Properties of complex 'wicked' problems, incorrect problem identification approaches, developing frameworks to tackle such approaches, visioning for desired futures, a feasible framework to incrementally develop emergent solutions that tackle problems at effective scales.

In order to find the problem that needs to be solved, the first phase in the procedure is to deviate from the initial problem statement. The second stage is to come to a new understanding of how the problem should be defined. The objective of the third stage is to generate ideas and come up with as many potential answers to the issue as feasible (Johannessen,2019).

## 1.3 Objectives and Methodology Exploration

### *1.3.1 Urban ecological capacities*

Throughout history, humans have created cities to support their societies as an expression of culture, for trade, safety, power or, dominance. While these cities have contributed to progress, their growth has often been guided by traditions and trial-and-error processes due to their emergent nature. Attempts to plan and control cities under a central planner have resulted in disordered emergence, a consequence of applying linear sciences to urbanism. Urbanity relies on the cooperation and mutual support of large numbers of people in close proximity, making it inherently emergent. Understanding the science of emergence is crucial in inventing a fully emergent urbanism capable of resolving the complexities of a sustainable city in the 21st century (Helie, 2012).

While urban systems are often seen as disconnected from nature, they are in fact tightly linked to ecological systems through matter flows. Ecological matter flow in urban systems refers to the movement of resources, materials, and waste through an urban environment. These flows are driven by human activities such as production, consumption, and disposal, and are influenced by a range of factors including infrastructure, technology, and socio-economic conditions. The impact of these flows on the environment can be significant, with many urban systems contributing to environmental degradation through processes such as pollution and resource depletion. Understanding and managing matter flows in urban systems is therefore crucial for achieving sustainable urban development and reducing the ecological footprint of cities.

Capacity refers to the ability of ecosystems to renew the resources that people require from those surfaces. Living organisms, including humans, compete for space. The biocapacity of a given surface area denotes its ability to regenerate the resources demanded by people. Biocapacity is a measure of the ecosystem's potential

| | Built-up Land | Carbon Foot Print | Crop Land | Grazing Land | Forest Land | Fishing Ground |
|---|---|---|---|---|---|---|
| Food | | | | | | |
| Shelter | | | | | | |
| Mobility | | | | | | |
| Goods | | | | | | |
| Services | | | | | | |
| | | | | | | |

(Fig-12) Consumption land use matrix. CLUMs are produced using Multi-Regional Input Output (MRIO)-based Footprint data, which is used to understand the flow of resources through the global supply chain. Each land use type contributes in some capacity to the overall chain (Global Footprint Network 2023).

to generate biological resources that are utilized by humans, as well as to absorb waste produced by humans, within the existing management and extraction techniques. Climate, management, and the proportion of the area that is considered beneficial inputs to the human economy can all affect biocapacity, which may fluctuate from year to year. The National Footprint and Biocapacity Accounts use the yield factor and appropriate equivalence factor to calculate the biocapacity of an area, which is usually expressed in global hectares. (Global Footprint Network 2023)

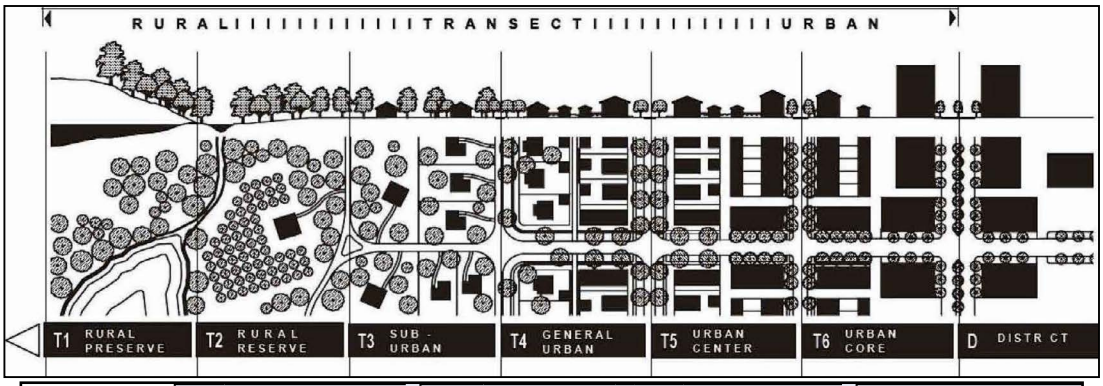
Among the mentioned land use types, Urban environments have reduced ecological capacities due to various reasons such as the replacement of natural ecosystems with impervious surfaces like buildings and roads, which prevent the natural infiltration of water and alter the hydrology of the landscape. Urbanization also leads to the fragmentation of habitats and the loss of biodiversity, as natural habitats are replaced by buildings and other infrastructure. Urban areas also generate a large amount of waste, which is often not properly managed and can pollute the environment. Moreover, urban environments are characterized by high levels of energy and material consumption, which further deplete natural resources and contribute to climate change. All of these factors contribute to the reduced ecological capacity of urban environments.

Based on the Consumption land use matrix, it can be inferred that all iterations of human developed or human altered landscapes contribute to the depletion of biocapacity in an interconnected chain. However, for the feasibility of problem-solving there are frameworks that exist to understand landscapes in a way that their complexity might not be compromised.

### *1.3.2 The Urban transect*

The landscape transect concept is a framework used in landscape architecture and urban design to understand and analyze the relationship between the natural environment and human activity in a specific location (Duany & Talen 2002). The transect is a cross-sectional line that traverses different land uses and ecological systems, providing a way to explore and understand the patterns and processes that shape a particular place. This approach emphasizes the importance of context and site-specificity in design and helps to identify opportunities for sustainable development that support the needs of both humans and the natural environment. By considering the various scales of the landscape, from the individual building to the larger ecological system, the landscape transect provides a comprehensive perspective for design and planning that considers the ecological, social, and economic dimensions of a site (Pape 2015).

The transect concept was initially introduced by Alexander Von Humboldt




| | ARTICLE 2 REGIONAL SCALE PLANS | ARTICLE 3 & ARTICLE 4 COMMUNITY SCALE PLANS | | ARTICLE 5 BUILDING SCALE PLANS |
|---|---|---|---|---|
| | A. Regional Sectors | B. Community Units | C.Transect Zones | Standards |
| Open Lands | O1 Preserved Open Sector | None | T1 Natural Zone<br>T2 Rural Zone | |
| | O2 Reserved Open Sector | None | | |
| New Development | G1 Restricted Growth Sector | CLD Clustered Land Development | T2 Rural Zone<br>T3 Sub-Urban Zone<br>T4 General Urban Zone | |
| | G2 Controlled Growth Sector | CLD Clustered Land Development | T2 Rural Zone<br>T3 Sub-Urban Zone<br>T4 General Urban Zone | Building Disposition<br>Building Configuration |
| | | TND Traditional Neighborhood Development | T3 Sub-Urban Zone<br>T4 General Urban Zone<br>T5 Urban Center Zone | Building Function<br>Parking and Density |
| | G3 Intended Growth Sector | TND Traditional Neighborhood Development | T3 Sub-Urban Zone<br>T4 General Urban Zone<br>T5 Urban Center Zone | Parking Location |
| | | RCD Regional Center Development | T4 General Urban Zone<br>T5 Urban Center Zone<br>T6 Urban Core Zone | Landscape Standards<br>Signage Standards |
| Existing Development | G4 Infill Growth Sector<br>G5 Sprawl Repair Sector | INFILL TND Traditional Neighborhood Development | T3 Sub-Urban Zone<br>T4 General Urban Zone<br>T5 Urban Center Zone | Supplementary Modules |
| | | INFILL RCD Regional Center Development | T4 General Urban Zone<br>T5 Urban Center Zone<br>T6 Urban Core Zone | |
| Other | | | CB Civic Building<br>CS Civic Space | |
| | | SD Special District | SD Special District | |

(fig-13)Nesting relationship of the scales of planning addressed in the SmartCode.The The six normative Transect Zones are not applied at the regional scale, as they are used for municipal zoning or to achieve balance in private developments (center for applied transect studies 2003).

to study the distinguishing features of natural environments, including wetlands, shorelines, and uplands. The purpose of the transect was to identify the various constituents that constitute habitats and ecosystems.

"*The answer lies in the functional implications of formal geometries in the urban pattern*" (Major 2013). The Urban Transect uses formal variables to relate to the functional use of the city. The transect specifies a geometric logic for streets, but the urban pattern above the level of the street is left to design professionals. However, the essential dynamics of form and process affecting urban functions are realized in cities. The deformed grid layouts of organic cities possess a consistent geometric logic underlying their apparent disorder (Hillier 1999). The physical arrangement of space has a direct relation to social life as it provides material preconditions for patterns of movement, encounter, and avoidance that are the realization of social relations (Major 2013).

The urban transect comprises six zones, distinguished based on the intensity of the built physical features, and social character. The basic idea of the transect is that specific forms and elements are suitable for specific environments. As urbanity increases, the complexity, density and intensity of the transect increases. Elements such as lighting, plantings, setbacks, thoroughfare design, and building heights change with the increasing level of urbanization(Pape 2015).

*1.3.3 Urban green infrastructure practices*

Urbanization is a rapidly growing phenomenon; as more people move to cities with this comes an increasing demand for resources and infrastructure. This has resulted in a reduction in the ecological capacity of urban areas, leading to a decline in the quality of life for urban dwellers. However, the implementation of green infrastructure in urban areas has been shown to increase the biocapacity of these zones. Green infrastructure, such as parks, green roofs, and urban forests, can provide a variety of ecological benefits, including improving air quality, reducing the urban heat island effect, and enhancing biodiversity. Research has shown that these types of green infrastructure can significantly increase the biocapacity of urban areas (Elmqvist et al., 2013; Gómez-Baggethun et al., 2013).

Urban transects refer to the different zones of development ranging from dense downtown areas to suburban neighborhoods and rural outskirts. Green infrastructure, on the other hand, refers to the network of natural and semi-natural areas that provide environmental and social benefits to urban areas, such as parks, green roofs, and urban forests. In planning , terms they are often referred to as gray and green infrastructure From this description, it is simple to visualize that the two concepts are arranged along a gradient. Elements of the physical world can be encoded with this information for representation and modeling purposes.

To achieve this, we delve into the socio-ecological aspects of the urban landscape and its impact on people's perceptions. Our aim is to raise awareness and foster a deeper connection between the urban population and nature. Despite the challenges posed by the densification and diversification of urban centers, which often result in reduced ecological capacities, human beings still crave a connection with nature. This is where the concept of "green infrastructure" comes into play, where the focus is on creating urban nature that is tailored to human needs and expectations. Our objective is not to simply add static objects that are fragments of elements reminiscent of nature to the urban fabric but rather to uncover their emergent properties that have a functional, experiential, and multi-faceted impact beyond the sum of their individual physical elements.

The value of green or natural infrastructure can be superficially grouped into distinct categories, however it is easy to understand that these benefits are intertwined. This distinction however helps to understand stakeholder perceptions and value can be assigned to green elements and planning bodies can better understand how to communicate with the public. Each design cannot fully exploit all the benefits of a tree. Although additional benefits are possible, they must not come at the expense of the primary objective. The intended use of the tree determines the primary objective, which establishes the design framework. (Crabtree 2014).

The Transect is a valuable tool for comprehending the context of a design and organizing which principles to apply. It highlights the fact that a design in a rural area should not be the same as one in a densely populated downtown neighborhood. Consequently, the primary purpose of planting a tree in nature differs from that in an urban setting (Crabtree 2014).

Based on the vegetation management practices (Crabtree 2014), each transect in an urban setting comes with its own challenges but at the same time, a starting point from which a problem can be understood and solutions can be formulated. As discussed earlier, framing

| **Economic** | **Health/social** | **Ecological** |
|---|---|---|
| Increase Property Values | Improve Human Health | Reduce Greenhouse Gases |
| Enhances Sense of Place | Provide Shade | Improve Air and Water Quality |
| Reduce Cooling Costs | Create Visual and Sound Buffers | Decrease Urban Heat Island Effect |
| Increase Economic Stability | Improve Neighborhoods | Reduce Energy Consumption |
| Reduce Expenditures on Gray Infrastructure | Create Walkable Streets | Decrease Top Soil Erosion |
| Longer Pavement Life | | Provide Wildlife Habitat |
| Reduces Storm-water Runoff | | |

(table-6) benefits of green infrastructure (Hall, Vonderscher & Adkins 2010).

the problem is the first and foremost important step of emergent planning visions.

*1.3.4 Planning for emergent behaviors*

With all the discussed frameworks and principles, most elements are currently described as either physical entities or ideas that govern system behaviors, but as mentioned, living systems are more than the sum of their parts. They arise from the interactions and relationships between their individual components. They are not simple, static objects, but rather dynamic and ever-changing entities. As noted by Fritjof Capra in his book "The Web of Life," *living systems are "networks of processes that continually interact with each other, forming patterns and structures of great complexity.*" This emergent behavior is a result of the system's capacity for self-organization and adaptation, allowing it to respond to changes in its environment and maintain a state of balance.

The study of living systems requires a holistic approach that takes into account the interdependent relationships between its parts, as well as the larger context in which it exists. Understanding the emergent properties of living systems is essential for developing sustainable and resilient solutions to complex environmental and social challenges.

One approach to this is interpreting urban elements as 'agents' that populate and may move through space and time, interacting with other agents that fall within their sphere of influence and produce expected or unexpected results. The predictability or lack of it can help keep this representative model open to unexpected changes, as it can be encoded with the ability to self-organize in reaction to disturbances.

The concept of decentralized or multi-agent systems bring a shift in the traditional hierarchy in urban design. While hierarchy is crucial in urbanism, the agent-based logic flattens it out during the design process, treating all elements of the urban fabric as having agency and allowing them to interact without a sequential design hierarchy. Instead, the hierarchy of intensities at a macro scale emerges as a result of their self-organizing operation.

This idea of 'agency' operates through two main processes: utilizing design agents to self-organize urban matter and encoding intelligence into urban elements and topologies (Roggema 2020).

*1.3.5 Agent based modeling*

Agent-based modeling (ABM) is a relatively new approach to modeling that has gained popularity among social scientists, particularly those studying urban and geospatial phenomena, as it provides an effective way to tackle complex and dynamic processes. As a result, the research on ABM has rapidly expanded over the past two decades and covers a wide range of topics (Chen, 2012).

The key idea in this model is the idea of an "agent". Defining the concept of an agent is essential for understanding agent-based models. However, there is no universally accepted definition. Some definitions are basic and loose, while others are elaborate and rigorous. Autonomy and social ability are two central properties of an agent, according to many researchers. An agent must be able to operate independently, make decisions, and interact with other agents to complete tasks. These properties distinguish agent-based systems from other software paradigms. A comprehensive definition of an agent is presented as "a computer system, situated in some environment, that is capable of flexible autonomous action in order to meet its design objectives." (Chen, 2012).

| **Agents** |
|---|
| Attributes |
| Behavioral rules |
| Memory |
| Resources |
| Decision-making sophistication |
| Rules to modify Behavioral rules |

(Table-7) An agent in its environment. After Macal and North (2005).

*1.3.6 Cellular Automata as methodology*

Cellular automata is one of the possible methods to use for such transition design because it allows the modeling of complex systems that involve multiple variables and feedback loops, which are key characteristics of the living systems, socio-technical systems, and wicked problems that transition designers seek to understand and intervene upon. By simulating the interactions of simple units, or cells, according to a set of rules, cellular automata can generate emergent behaviors that help us understand how a system might respond to different interventions or changes in conditions.

M. Amorim, R. Mateus, and J. Freitas propose a cellular automata model that can be used to explore the effects of different urban design interventions on the sustainability of cities. The model simulates the interactions between different variables such as population density, land use, transportation modes, and energy consumption, and generates different scenarios based on different input parameters. The authors argue that this type of modeling can be useful for transition design because it allows designers to explore the effects of different interventions on a complex system and to identify potential unintended but welcome consequences and emergent behaviors.

### *1.3.6 Objectives and aims*

With all the information gathered, and possible approaches mentioned. The aim of this thesis will be to test the various interconnected ideas mentioned in the literature so far.

**Problem-identification and visions:**
Reframing the issue of green infrastructure interventions in urban environments based on stakeholder perceptions and ecological goals. Exploring if synergy can be found between ecological and socio-economic values.

**Time and scale-based green infrastructural planning:**
Explore rules that can govern optimum green infrastructure planning in dense urban environments and represent them in dynamic models that react to evolving information.

## 2. Methodology

### 2.1 Overview

To better direct towards relevant methods, it may be useful to provide a overview of the main ideas learned in the previous section.

» The 'value-laden' Complexity of the built world needs to approached as ill-structured and dynamic as it is **observed**.

» Problems such as decreased ecological capacities of urban zones are complex and ill-structured problems that influence diverse stakeholders, creating **co-linkages** between multiple stakeholder values can help an initiative gain traction and increase adaptability.

» Transition design approach is to 'backcast' from a co-created **vision** and form tangible goals in the near future that can help steer to a desired state.

» Emergent behaviors are potentials of 'intelligent' agents & their interactions, that populate a system.

**Methodology Overview**

| Objectives | Research Design | Tools and Material | Expected outcome |
|---|---|---|---|
| Reframing the issue of green infrastructure (GI) interventions in urban environments based on stakeholder perceptions and ecological goals. Exploring if synergy can be found between ecological and socio-economic values. | Literature review to build understanding of valuation systems. How interpretation of data and stakeholders interactions can define problems and possible solutions. | The Methodological Assessment Report On The Diverse Values And Valuation Of Nature (IPBES, 2022) | A valuation framework that is in-line with views of transition design, particularly concerning GI planning in an Historical Neighborhood infiill transect* |
| Explore rules that can govern optimum green infrastructure planning in Historical Neighborhood infiill transect* and represent them in dynamic models that react to evolving information. | GIS-based (Geographic Information System) encoding valuation into a 2-D grid-cell, interpreting resulting 'hot-spots'. | Conceptual Participatory Study Of Seifrova Street Transect In Praha Czechia. (IPR, 2020)<br>Seifrova Street (Praha-Zizkov) Transect Geographical And Built Urban Element Openmap Data. (IPR, 2022) | Concentration of values and emergent behaviors made visible, to incorporate into decision-making processes. |

*** Case Study transect Praha-Zikov** The concept of a historical neighborhood infill transect is based on the urban transect concept, which is a framework that categorizes urban areas into different zones or transects based on their density, land use, and design characteristics. Infill development refers to the process of building on vacant or underutilized land within an existing urban area, often in established neighborhoods. (Center for applied transect studies 2003).

The historical neighborhood infill transect is a specific application of the urban transect concept that focuses on infill development in historical neighborhoods. It involves identifying and characterizing the different types of development that can occur within these neighborhoods, such as small-scale infill, larger-scale redevelopment, and adaptive reuse of historic buildings. The transect can be used as a tool to guide the design and planning of infill projects in these areas, with the aim of preserving the character and heritage of the neighborhood while accommodating new development. (Center for applied transect studies 2003).

(Table-7). Overview of the two-part methodology (Author).

## 2.2 Part One: Valuation systems

*2.2.1 Introduction: IPBES Report The Diverse Values And Valuation Of Nature (2022)*

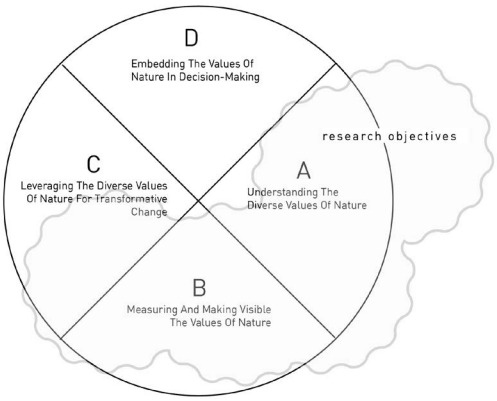
IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) is a self-governing intergovernmental organization, which is composed of approximately 140 member governments. Its primary objective is to provide policymakers with impartial scientific assessments concerning the status of the planet's biodiversity, ecosystems, and their contributions to humanity, as well as options and actions for safeguarding and using these essential natural resources in a sustainable manner.

*'The Assessment of the Diverse Values and Valuation of Nature'* originated from a decision made by the IPBES Plenary at its sixth session (IPBES 6), which was held in Medellin, Colombia in 2018. The Plenary based its decision on the scoping report, which the Plenary approved at its fourth session (IPBES 4) in Kuala Lumpur, Malaysia in 2016. At its ninth session (IPBES 9) in Bonn, Germany in 2022, the Plenary assessed the Assessment of the Diverse Values and Valuation of Nature and approved its summary for policymakers, as well as accepted its chapters (IPBES, 2022).

The report examines the relationships between different world-views and values and includes a typology of values. It also offers guidance on designing and implementing methods for valuation and embedding the diverse values of nature into decision-making and policymaking. Additionally, the report highlights the importance of key capacities required to work with multiple values in order to bring about transformative change across different stakeholders and institutions.

| Main section themes of the report | |
|---|---|
| A | Understanding the diverse values of nature |
| B | Measuring and making visible the values of nature |
| C | Leveraging the diverse values of nature for Transformative change towards sustainability |
| D | Embedding the values of nature for transformative decision-making for sustainability |

(Table-8)Structure of the assessment of the diverse values and valuation of nature(IPBES, 2022).




(Fig-14) Research objectives based on the IPBES assessment structure (Author, 2023).

*2.2.2 Understanding Values Typology*

'The theory of value' is a branch of philosophy that seeks to understand the idea of value and what makes something valuable. This process is influenced by various factors such as personal beliefs, cultural norms, and environmental factors (Mark 2021).

In terms of environmental value, it refers to the assignment of value to natural resources, ecosystems, and biodiversity. The value of these entities can be assessed in various ways, such as their economic, ecological, or cultural significance. For instance, a forest may be valued for its ability to regulate the climate, provide habitat for wildlife, or be a source of timber for human use.

Individuals perceive the reality through **world-views.** This lens shapes how people perceive and interpret the world around them, as well as how they act upon their perceptions.

**Knowledge systems** are constantly evolving and encompass a range of knowledge, practices, and beliefs regarding relationships between living beings and nature. Academic knowledge systems are based on formal and generalizable methods, while indigenous and local knowledge, is highly diverse and grounded in territory and sociocultural identity.

**Broad values** are general moral guiding principles and life goals that are shaped by people's world-views and beliefs. These values are often embedded in a society's institutions, including informal social conventions and formal rules, and they can serve as the foundation for people's specific values of nature.

**Specific values** ; 'Intrinsic value' refers to the inherent value natural entities possess, independent of any benefits they may provide to humans. On the other hand, 'instrumental value' refers to the value that these entities hold in terms of their usefulness or benefit to humans. (Rolston 1988, Callicott 1989, Norton 1984), there are recent developments in the concept of 'relational' values which reflect the qualities of the relationships between humans and nature, such as care, place attachment and spiritual meanings.

**Value indicators** are quantitative measures and qualitative descriptors that reflect nature's importance to people.

| **Word-views** |
|---|
| Anthropocentric |
| Ecocentric |
| Pluricentric |
| Cosmocentric |

| **Knowledge systems** |
|---|
| Academic |
| Indigenous/local |

| **Broad values** |
|---|
| Guiding principles and life goals.<br>Livelihood, prosperity, health ,belonging, responsibility, harmony with nature |

| **Specific Values** |
|---|
| Instrumental |
| Intrinsic |
| Relational |

| **Value Indicators** |
|---|
| Biophysical |
| Monetary |
| Sociocultural |

(Table-9) Values Typology: presented as distinct groups however in reality these values are nested, and a given approach is a amalgam of these typologies (IPBES, 2022).

*2.2.3 Aggregation of values:*

Measuring the diverse values of nature use a wide range of biophysical, monetary, and sociocultural indicators, but creating comparisons presents challenges in cases where indicators don't share the same metrics. However, a workaround for incompatible values indicators is that they can be discussed in parallel with affected parties. Economic values are have been extensively documented and standardized while Social values often involve measuring changes in the quality of life of individuals and aggregating them (IPBES, 2022).

*2.2.4 Valuation methods*

In order to make visible, the diverse values people hold for nature, valuation is an intentional and explicit process in which agreed-upon methods are applied in order to assess and elicit such values. The method can naturally develop based on desired outcomes so the important choices to make is the trade-offs between the characteristics; relevance, robustness and resources.

| **Valuation Methods** |
|---|
| Nature-based |
| Statement-based |
| behavior-based |

| **Valuation Method trade-offs** |
|---|
| Relevance (i.e., salience in terms of the values that can be used in decisions) |
| Robustness (i.e., reliable, consistent and socially representative) |
| Resources (i.e., time, financial, technical and human resources). |

(Table-10) Valuation methods and their characteristics (IPBES, 2022).

*2.2.5 Conclusions: The relevance of research and study introduction*

As proposed early, the urban neighborhood infill is the target transect. Urban infill development is often driven by the need to maximize land use and increase economic benefits, but this can result in a reduction of ecological capacity and the degradation of the local environment. This tension between economic development and environmental sustainability poses significant challenges, particularly in urban cores where space is limited. Therefore, by studying this transect, the aim is to gain a better understanding of the trade-offs and conflicts between economic development and ecological sustainability in urban environments, and to identify potential strategies for balancing these competing demands. For this reason it is necessary to first gain and visualize values individuals hold of their shared public spaces, potential and limitations their environment elicit, and find gaps that can be bridged by research and building knowledge-base.

Based on the IPBES frameworks, the study can be explained as follows;
"Understanding relational values individuals extract from their share spaces, which will be sociocultural in nature, for this reason the method will be statement-based that is to have some spatial reference. Among the characteristics, relevance has priority, as the values should be tested for their potential contribution to decision making process in spatial planning"

| Main section themes of the report | |
|---|---|
| A | Understanding the diverse values of nature |
| B | Measuring and making visible the values of nature |
| C | Leveraging the diverse values of nature for Transformative change towards sustainability |
| D | Embedding the values of nature for transformative decision-making for sustainability |

| Word-views |
|---|
| Anthropocentric |
| Ecocentric |
| Pluricentric |
| Cosmocentric |

| Knowledge systems |
|---|
| Academic |
| Indigenous/local |

| Broad values |
|---|
| Guiding principles and life goals.<br>Livelihood, prosperity, health ,belonging, responsibility, harmony with nature |

| Specific Values |
|---|
| Instrumental |
| Intrinsic |
| Relational |

| Value Indicators |
|---|
| Biophysical |
| Monetary |
| Sociocultural |

| Valuation Methods |
|---|
| Nature-based |
| Statement-based |
| Behavior-based |

| Valuation Method trade-offs |
|---|
| Relevance (i.e., salience in terms of the values that can be used in decisions) |
| Robustness (i.e., reliable, consistent and socially representative) |
| Resources (i.e., time, financial, technical and human resources). |

(Table-11) extracted ideas from the IPBES framework to built the case (IPBES, 2022).

The **relational values** that locals would have about their public spaces can vary depending on cultural, social, and economic factors (Chiesura, 2004, Tuan,1977,Gieryn,2000) .However, some common relational values that locals might have about their public spaces include:

*Sense of community:* Locals may value public spaces that provide a sense of community and allow them to connect with others who share similar interests or backgrounds.

*Safety and security*: Locals may value public spaces that are safe and secure, both in terms of physical safety and the absence of criminal activity. This can include welcoming environments, presence of crowds or activities that are generally perceived to be positive.

*Accessibility:* Locals may value public spaces that are easily accessible, both in terms of physical accessibility for those with disabilities and convenient transportation options. This can include sidewalks, bike lanes, and public transportation.

*Cultural significance:* Locals may value public spaces that have cultural significance or historical importance to the community. This can include monuments, landmarks, and public art.

*Environmental sustainability:* Locals may value public spaces that prioritize environmental sustainability, such as green spaces that promote biodiversity,

Overall, these values are rooted in a desire for a sense of community, safety, accessibility, cultural significance, and environmental sustainability.

## 2.3 Site Study: Prague-Zizkov

### *2.3.1 Context-Sensitivity In The City Of Prague*

Prague, the capital city of the Czech Republic, is a historic and cultural hub that has been shaped by centuries of rich history and influenced by different historical periods, such as Gothic, Renaissance, Baroque, and Art Nouveau, among others. Perched on the banks of the Vltava River, the city is renowned for its stunning architecture, beautiful old town and iconic landmarks. The city's cobblestone streets, picturesque squares and charming alleys are a testament to its rich cultural heritage. Despite suffering some damage during the World Wars, Prague has managed to maintain its historical charm and cultural significance. Today, Prague is a bustling metropolis that attracts millions of visitors every year who come to explore its rich history. As a city that has managed to maintain its cultural heritage while also adapting to modern times, Prague is a prime example of how cities can strike a balance between preserving their past and embracing their future.

Prague has undergone significant modernization over the years, adapting to the changing needs of its residents and visitors. One of the most visible signs of modernization is the city's expanding transportation network, including the addition of modern tram and metro systems, and the upgrading of roads and bridges. The city has also invested heavily in new commercial and residential developments, including modern shopping centers, office buildings, and high-rise apartments. It is easy to understand that maintaining it's rich historical character and modernization of the city is a driving vision for the city.

### *2.3.2 IPR Conceptual Studies*

The IPR (The Prague Institute of Planning and Development) is the city's main policy-making unit for urban architecture, planning, development, design, and administration. Since 2015 it has executed the initiative of "conceptual studies" which has been introduced as "*A non-binding vision and a guide for change in a territory that does not work as it has potential for.*" (IPR 2022). These studies served as the foundation for a number of urban renewal initiatives in Prague. 18 completed conceptual studies are currently publicly viewable on the institute's official website as of March 2023.

According to IPR the expected utility of the studies is explained as "To improve and modify a public space in the city, the initial step is to create a conceptual study.

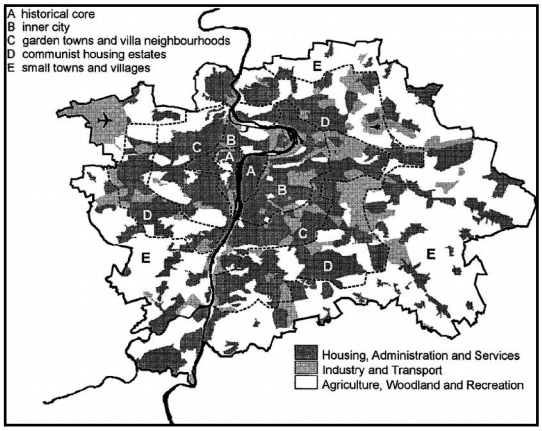
This study evaluates the current situation, determines priorities, proposes a direction for modifications, and coordinates planned interventions in the locality. Based on the study, "the modifications may include wider sidewalks, new alleys, fewer barriers, or the addition of bike lanes. A well-executed conceptual study ensures that the details of the modifications are better planned"(IPR, 2022).

The conceptual studies, which are overseen by the IPR, are frequently carried out in partnership with private entities like design studios. So far these studios have been successful in presenting the study results with in-depth technical and informative content in a wide range of visual aids. The most common strategy entails installing an IPR Prague information container in the area to enable locals to meet and converse with coordinators, IPR Prague personnel, town hall administrators, or architects and even infrastructure managers (IPR 2021). Additionally, guided tours and surveys using smart technology have been utilized to gather statement-based data.

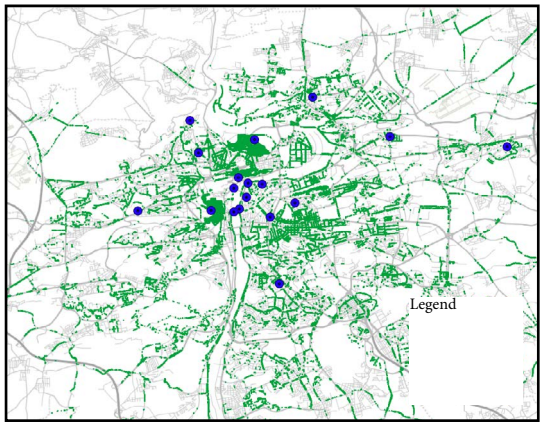
In terms of understanding stakeholder values, it can be deduced that the data collected via the studies have some level of reliability i.e., the robustness of the valuation versus the resources expended can be judged as a reasonable trade-off.

Both the strength and the weakness of the studies is that the reports are not standardized. Since they are outsourced, the knowledge base build is diverse enough to cater to specific context but it can be argued that momentum for a particular idea probably has not built-up because each transect has been studied, planned and executed as a stand-alone project.

Mapping the 18 projects shows that the focus has been certain historically significant streets and river embankments, mostly centered around the Prague old town.

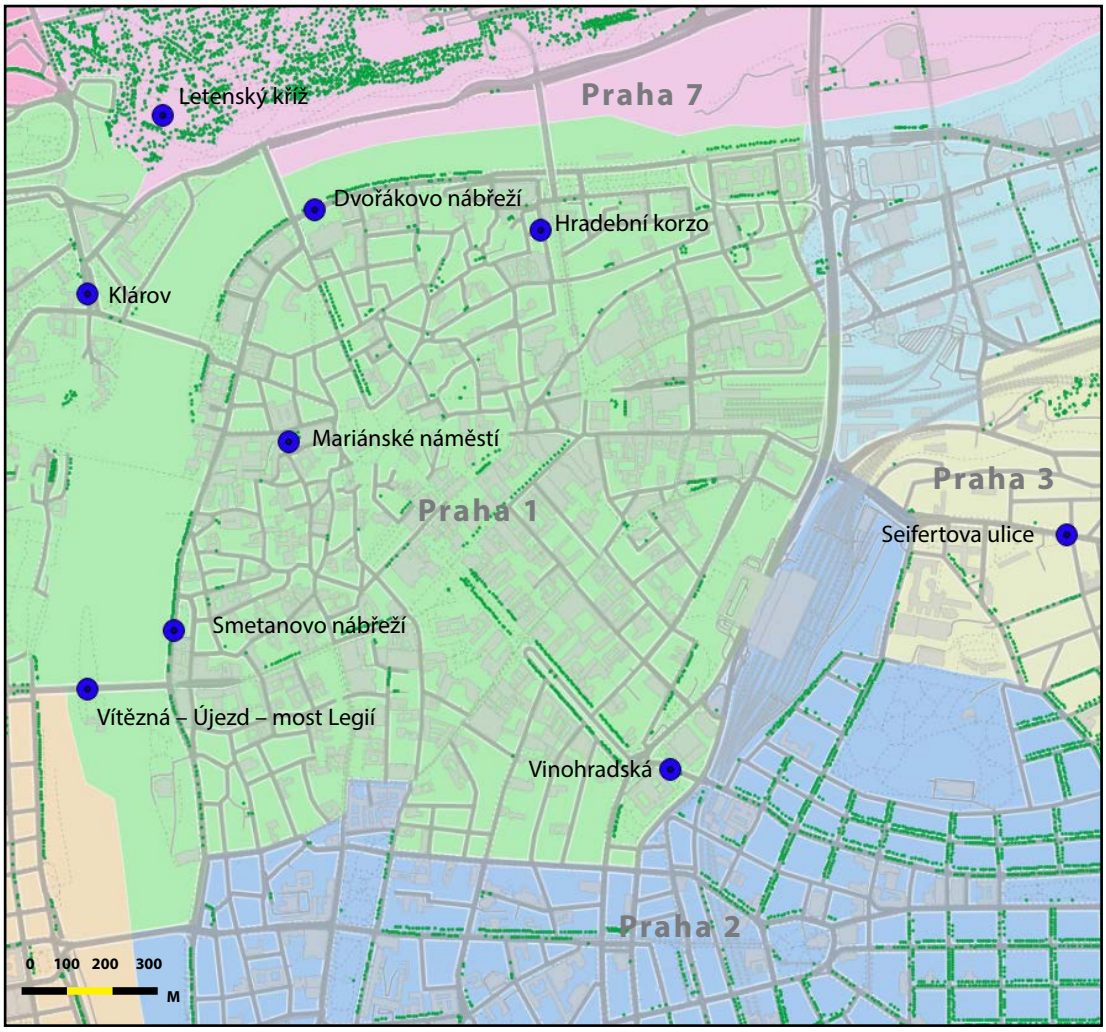



(Fig-15) Prague: urban spatial structure and land use. Source of data: IMIP - Institute of Municipal Informatics in Prague and URM - The City of Prague Development Office. S ( Sýkora, 1999).




(Fig-16) Prague: mapping of conceptual studies facilitated by IPR. ( Author, 2023)

This presents a potential of creating a network of ecologically-sound planning that can have a net positive if executed well.



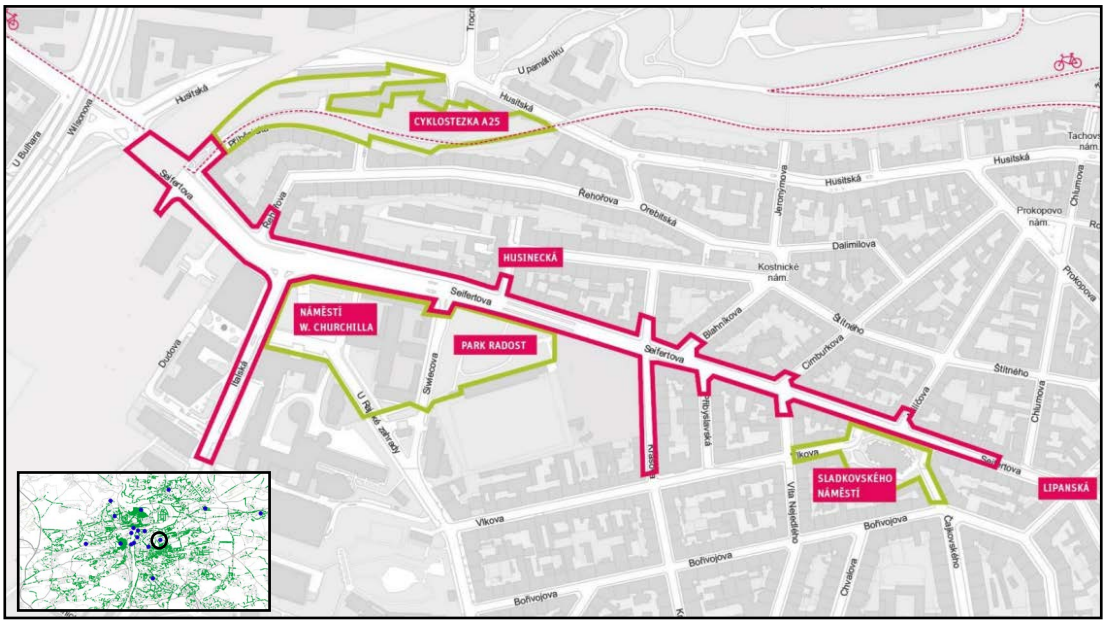

| | |
|---|---|
| Dvořákovo nábřeží | 2015 |
| Letenský kříž | 2017-2018 |
| Kampus Dejvice | 2021-2022 |
| Dopravní terminál Černý Most | 2021-2022 |
| Klárov | 2017 |
| Bělohorská | 2015-2016 |
| Mariánské náměstí | 2019 |
| Klapkova | 2015 |
| Hradební korzo | 2019 |
| Petřín | 2019-2020 |
| Vinohradská | 2015-2016 |
| Sídliště Baba | 2020-2022 |
| Náměstí OSN | 2016-2017 |
| Táborská/Na Pankráci | 2015-2016 |
| Nábřeží Stromovky | 2017 |
| Vítězná – Újezd – most Legií | 2016 |
| Smetanovo nábřeží | 2020-2021 |
| Seifertova ulice | 2021-2022 |

(fig-17) map showing the 18 conceptual studies with a focus on the 9 projects implemented in the old city core. The map is overlaid with the prague opendata tree data from IPR. Showing a weak link between the studies been done in locations lacking in green networks., a large number of proposals have plans for new tree plantings in the areas. (Author, IPR 2022).

(table-12) The list of 18 conceptual study locations and the study completion time-frame. Highlighted areas lie around the historical neighborhoods around the Prague old town. Most studies span several months, starting from planning to implementation to preparation of the study (IPR 2022).

The intention is to explore scalability of interventions as described earlier in the thesis. Thus understanding the conceptual studies are a key step in a larger infill development.

*2.3.3 Selected study: Seifertova ulice*




(fig-18) The Seifertova study scope defined by IPR. Pink outlines the actual planning site while green outlines areas that have a great relevance and influence over the street itself. ( IPR 2021)

The text summarizes the results of an Online survey among users the of Seifertova Street in Prague 3 district (Zizkov-Praha) and its surroundings.

The primary collection of suggestions from the general public served as a basis of the conceptual study and subsequent proposal of Seifertova Street prepared by IPR and architectural studio ARCHUM. Data collection took place in the form of an Online questionnaire from June 21 to 30, 2021 as an alternative to a public planning meeting due to the waning Covid-19 pandemic (Hanus, Vlasáková, 2021). The survey was promoted through public channels including an IPR booth, web portal, town bulletin boards & posters. The study was extended till Spring of 2022, where two guided walks with the representatives of the project took place. A public feedback hearing took place in the same week. The feedback meeting on the working design of the ARCHUM architekti, s. r. o. studio was attended by about 60 participants, who generated 78 aggregated suggestions for modifications of the submitted design (IPR 2022).

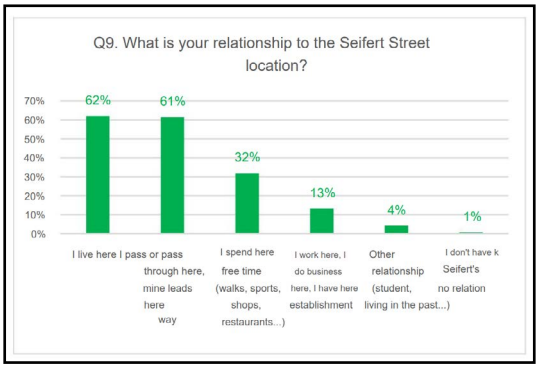
The study has been concluded and a proposal has been prepared for the revitalization of the street based on deduced results as of March 2023. However the content of the study, which was a combination of open-ended questions and specific statements that were utilized to elicit responses can be interpreted differently based on the idea of re-framing problems as described by the objectives of this thesis.

| **Questionnaire content** | **Relevance** (IPBES valuation methods characteristic) |
|---|---|
| Level of agreement or disagreement on given statements about the existing conditions of the study area (likert scale). | As the question statements have been pre-defined and are specific, their relevance is limited by the importance of each statement. |
| Geo-located comments/ observations about the study area. | Key information, responses were elicited based on ideas rather than statements, it has relevance in the framework of understanding and measuring relational values. |
| Geo-locating pre-determined problem (rainwater) in the study area. | As the question statement have been pre-defined and is highly specific, it's relevance is limited by the importance of the statement. |
| Open-ended descriptions about the future visions for the study area. | Open-ended question, the responses (n=166) have been aggregated into 11 distinct statements (Based on a public hearing n=60) These statements are an example of formation of 'shared values'. |
| Level of agreement or disagreement on given statements about the potential (typical)proposals in the study area (likert scale). | As the question statements have been pre-defined and are specific, their relevance is limited by the importance of each statement. |

(table-13) The Seifertova study survey evaluation. The objective is to determine which approach has relevance to the defined frame of understanding and subsequently visualizing relational values ( IPR 2021)

### *2.3.4 Relevance and Robustness:*

Based on the objectives of the study, local actors and affected individuals are key figures and their opinions and attitudes will determine the course of action. So it is essential to evaluate that the study can be relied upon. The reliability or the robustness (IPBES valuation methods characteristic) of the survey can be determined to be satisfactory as several channels were utilized to promote the survey and the resulting demographic is indeed the (commonly understood) stakeholders of the study area. However there is still concerns regarding the diversity or bias in the data collection approaches, which has been described in the IPBES framework as a common issue among data collection (exclusion of certain demographics). However within the scope of the thesis, this will not be explored due to limited resources needed to investigate (See chapter 3).




(fig-19) The Seifertova study survey Demographics (n=166) A total of 251 respondents accessed the survey and 166 answered from start to finish. The survey was capable of saving answers from respondents who did not finish, thus there is data from respondents with no-defined demographic category ( IPR 2021)

### *2.3.5 Mapping values*

The key content is the so-called 'feelings map', which was an optional activity that involved participants placing 'markers' on satellite imagery of the study area. Each individual was allowed up to 5 markers and only results that were 'understandable' were concluded in the report. The question asked specifically for **'values', 'potential'** and **'problems'.** In the context of this

thesis, these terms hold weight as they are not simply strengths or weaknesses. Their implications, as proposed by the author based on the IPBES framework, are as follows.

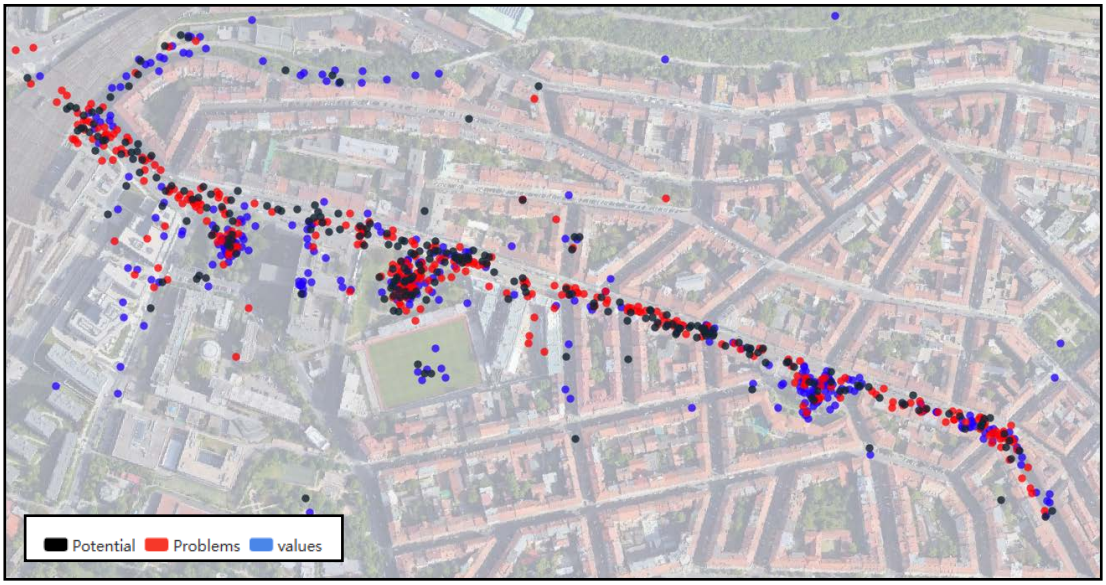
*'Problems'* : makes explicit, the relational values people hold about the public space and nature. What people "feel" or "sense".
*'Values'* : intrinsic but mostly instrumental values public space, and nature **hold in the present.**
*'Potential'*: intrinsic but mostly instrumental values public space, and nature hold **for the future**, understanding and knowing these values is key step in creating transformation as these values need to be in-line or be adapted to achieve ecological goals.

As introduced earlier, the relational values people hold of an urban environment is a complex set as not only nature, but anthropocentric worldviews such as economic goals, culture and sense of community elicit broad and specific values. In order to visualize, the statements collected in the study were encoded with the **shared values** as follows;

| |
|---|
| F=FUNCTION/USABILITY |
| S=SAFETY |
| C=COMFORT |
| A=AESTHETIC |
| E=ACCESSIBILITY |

(Table-14) Each assigned group is associated with multiple attitudes. Communication and feedback can facilitate the formation of shared values. These approaches to shared value formation can help legitimize decisions in situations that are complex, where values held at the individual scale cannot be incorporated directly into the process due to being highly specific (author).

A total of 910 markers (problems:340, values:312, potential:258) were placed on the free-to-use 'Google My maps' which generated a downloadable kml file (format used to display geographic data in an Online satellite map browser). The kml file for the study also recorded accompanying descriptions in the original Czech language that were translated into English using Google sheets translate tools.



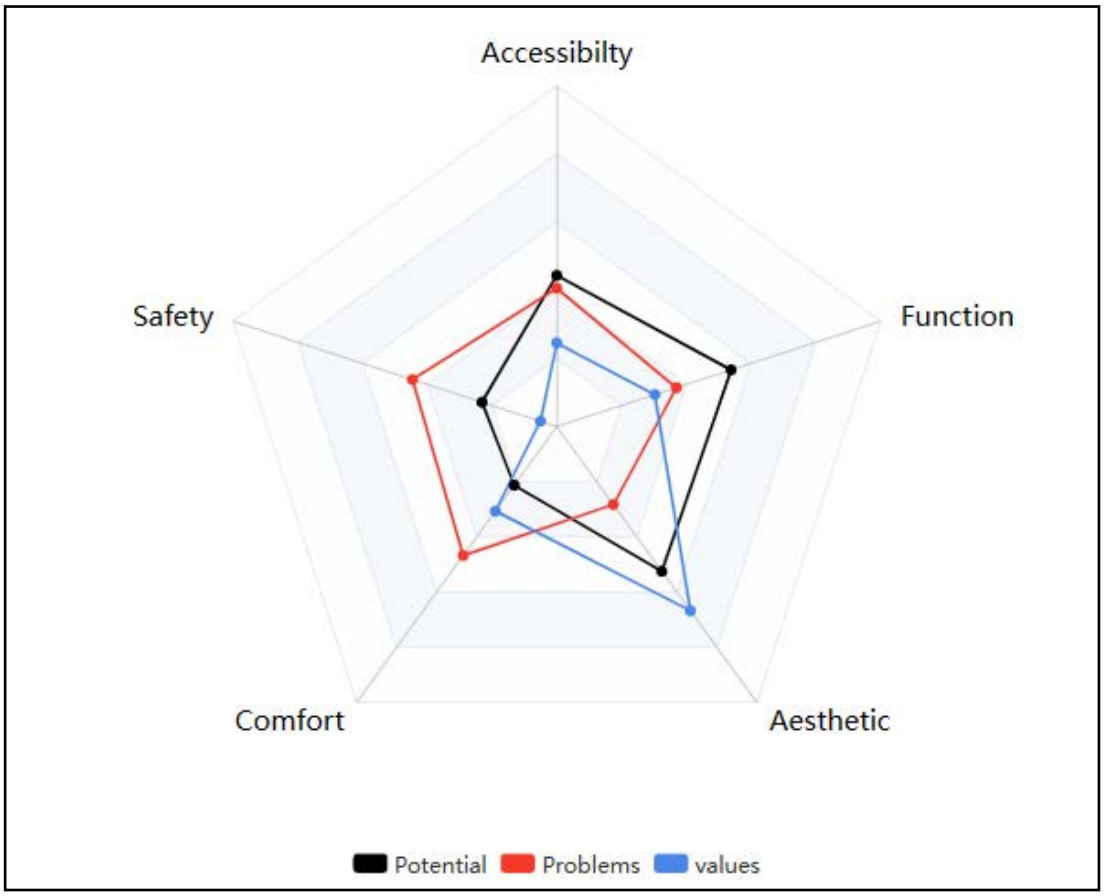

(fig-20) "feelings' map of the study participants. 'Values' marked in blue, 'potential' marked in black and 'problems' in red (Author, IPR 2021).

The resulting data was converted to 'shapefile' (format for storing information of geographic features) and was processed in QGIS 3.28.1-Firenze (open-source geographic information system desktop application).

Each comment was individually interpreted and associated with the closest shared values (F=FUNCTION/USABILITY S=SAFETY C=COMFORT A=AESTHETIC E=ACCESSIBILITY) each comment was associated with as many values it implied.

For example; Comments about the dirtiness and unwelcoming nature of certain places were associated with A=AESTHETICS and S=SAFETY and sometime C=COMFORT. Comments about the ease of use of sidewalks were associated with F=FUNCTIONALITY and E=ACCESSIBILITY and in some cases C=COMFORT. Micro-climates (hot, shade etc.) Were associated with C=COMFORT and comments associated with the presence of nature and trees (with no additional value such as comfort) were associated with A=AESTHETICS. A common recurring value was of the 'genus loci' of the place, associated with 'the Church of Saint Procopius', the modern high-rise 'Dum Radost' and the transportation stop 'Lipanska'. These values were associated with A=AESTHETICS.

The negative nature of the 'problems' set is not encoded. This can be worked into the model as a 'negative comment' implies the alternate positive value a location holds.

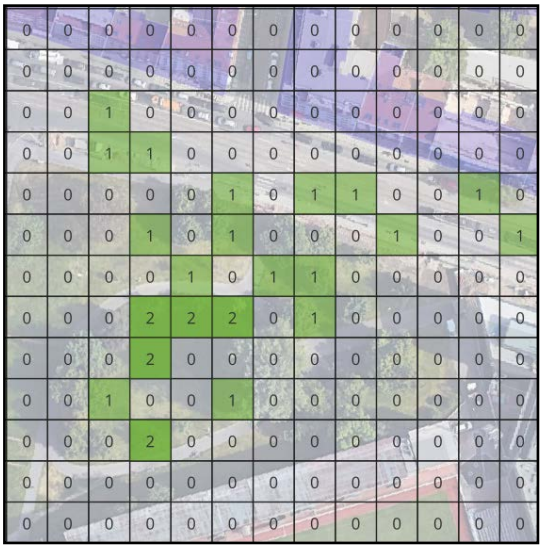



(fig-21) radar chart showing the distribution of the five shared values in the three categories of values,potential and problems (author).

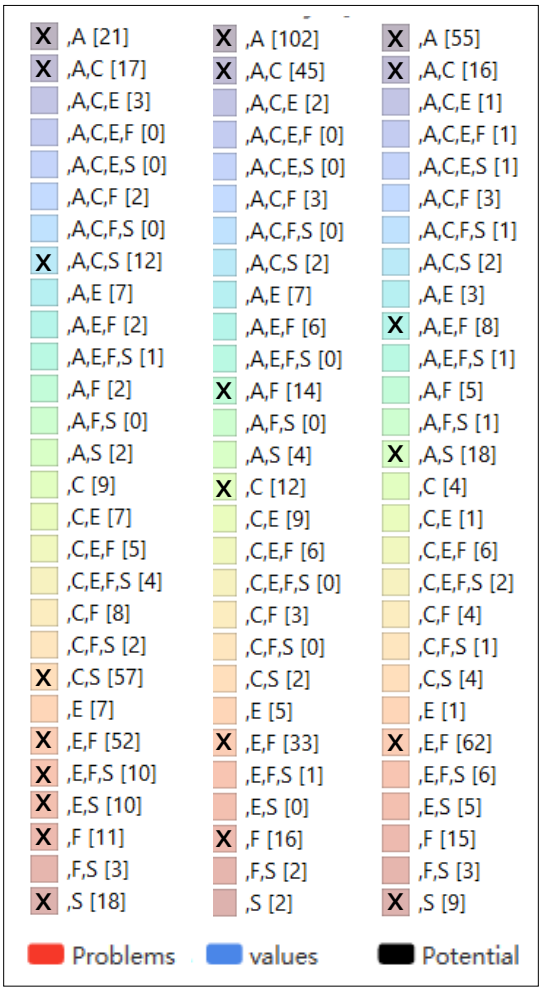
A total of 118 responses (potential:19,problems: 64, value:35),were eliminated from the dataset due to no descriptions, The full dataset with translations is available in the Appendix.

To visualize the distribution, variance and inter-relation of these shared values, a grid of 10 x 10m was overlaid till the extends of the study area (defined by IPR).

Using QGIS processing tools, each of the 3 sets with the five shared values was individually processed and joined into the study grid cell. It worked on the principle that all the codes (F,C,S,E,A) that fell insides the given cell unit would be transferred into the value of the cell. A given cell would show a count for every value for the markers detected inside that cell boundary. For representation, all five shared values among the 3 groups were also separated into a total of 15 layers.




(fig-22) 10x10m virtual patch showing the re-occurrence of 'aesthetic' potential (value) in the radost park area, specifically the center (author).

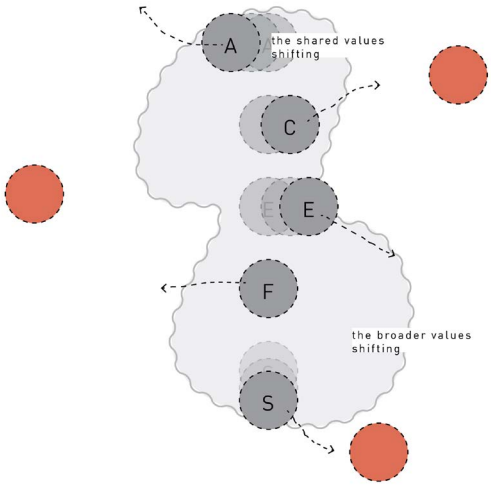



(fig-23) frequently grouped shared values in the dataset. (F=FUNCTION/USABILITY S=SAFETY C=COMFORT A=AESTHETIC E=ACCESSIBILITY) (author).

Most shared values have not been recorded as independent observations. For example, accessibility and functionality of street intersections appeared repeatedly in descriptions regarding the ease of access and altering function of location altogether (e.g., car parking to bike-friendly trails and solution to difficult slopes in the same intersections). As the data has been now been encoded into grid-cells, an aggregation of values can be processed based on proposed parameters .

Before establishing any value aggregation models, it is important to remember that the intention is to identify effective planning principles that work on a small scale but can also be scaled up to a larger area.

A object can hold a aesthetic value, a functional value or be a source of comfort or a threat to accessibility. These values and objects are variables and constants (only in a given time-scale) populating a space. On the principle of "agents" these objects and values, can be encoded into representative units, i.e., the grid cell. It is simple to visualize a dynamic value would be loosely associated with a cell and can change based on the neighboring cells that influence it. In the context of this study, it may be useful to explore what objects and values, that are in close proximity of the shared values, are directly the source of influence. If a relation can be established, theoretically altering these 'weighed' cells, towards which the shared values gravitate, can cause transformation in the broader values.




(fig-24) Shifting "weight" to shift shared values, causing transformation in broader values (author).

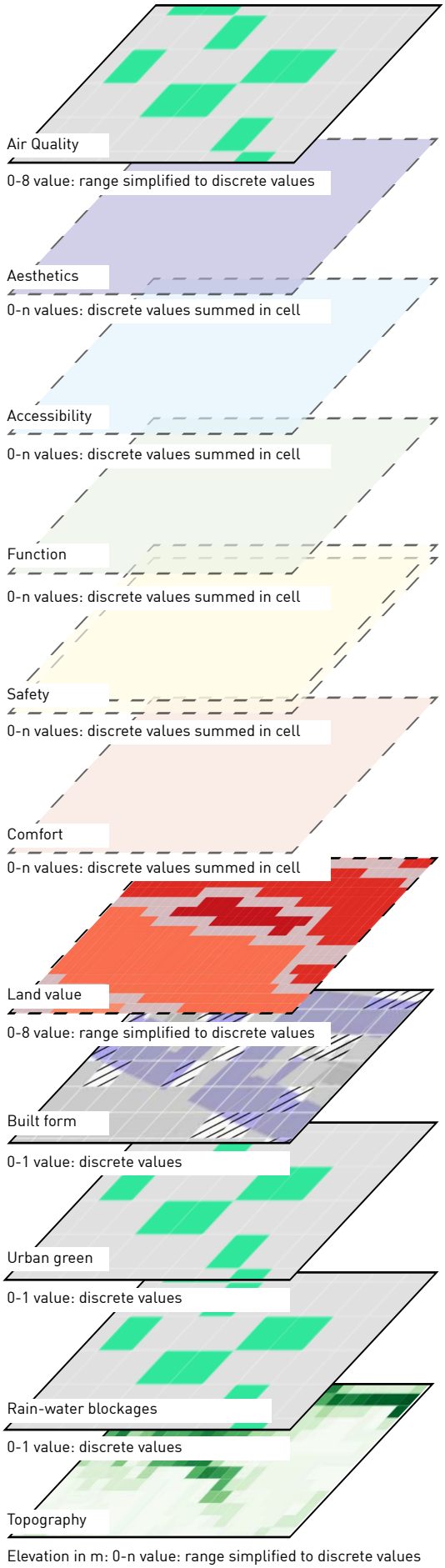
*2.3.6 Creating value linkages*

The process of mapping data onto the same grid size so that they can be compared on the same scale is called "grid interpolation". This involves taking scattered data points and assigning values to regularly spaced grid cells that cover the same area. This allows the data to be visualized and analyzed in a more standardized and consistent way, which can be useful when multiple agents are extracted and observed at different scales. For the feasibility of this study, all data is scale to the 10x10 m grid that is was the optimum scale for the conceptual study feeling maps markers.

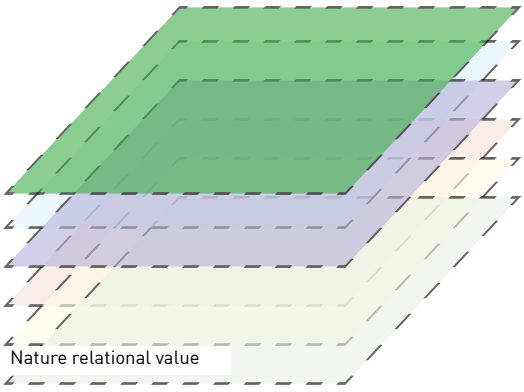
For the scope of this thesis, there is no structured approach to the selections of potential parameters or agents except repetition and iterating through possible combinations, inspired by the 'feelings map' study. (For example urban parks and safety 'problems' in their vicinities).

| **Physical Features** |
|---|
| Topography/substrate |
| Built solid and voids |
| **Shared Values** |
| Aesthetics |
| Utility/function |
| accessibility |
| Safety |
| Comfort |
| Land value |
| **Flow Of Energy And Matter** |
| Water regulation |
| Air regulation |

(table-15) Groups of parameters based on the specific study data (shared values). results of a iterative search process (author).




| |
|---|
| Air regulation |
| Aggregation of urban air quality, air ventilation and flow velocity |
| Aesthetics |
| Inspiration \|wonder \|connection \|appreciation |
| Utility/function |
| Instrumental values, usefulness |
| Accessibility |
| Serving diverse user needs |
| Safety |
| Sense of security |
| Comfort |
| Thermal, light, sound, air quality comfort levels |
| Land value |
| Often monetary value of built fabric arising from multiple parameters such as cultural, aesthetic functional values aggregated |
| Built solid |
| The degree of public and private nature of the space |
| Built void |
| In reference to lack of significant visual barrier and access barrier |
| Urban Green |
| Surface and Vertical greenery. |
| Water regulation |
| Efficiency of water regulating properties of the environment |
| Topography/substrate |
| Unmovable dimensions of the substrate |
| Nature specific values |
| Combination of all nature-positive comments in the survey |




(fig-25) The parameter, arranged in a logical order, their relations and direct influence can be key to understanding formation of certain values. (Author).

All datasets were obtained from the IPR open map data resources. Many values were further processed to be able to logically run aggregation processes. Including giving 'grades' to the more continuous datasets such as land value range or assigning a NULL or 1 to data points that were discrete points such as markers for water infiltration problems.

Once again, several combinations were tested to convert elevation and land values into comparable grid cell values. Additionally, all description of natural elements (mostly trees and parks) that were exclusively associated described as "positive" values, were aggregated into a separate groups of 'nature values'. The data was collected by searching for common nature-related vocabulary in the survey data. It was confirmed beforehand that, all mentionings of "nature" "green" "trees" etc. were described in a positive manner.

*2.3.6 Calculations : Moran I methods*

In order to confirm hypotheses and search for logical relations in spatial data, various spatial autocorrelation techniques are available. One of the most widely used methods is the Moran I statistic, which measures the degree of spatial clustering or dispersion in a dataset. By calculating Moran I values, it can be determined whether features that are close to each other in space are more similar or dissimilar in terms of their attribute values than would be expected by chance.

Selected descriptors and indicators that determine a degree of relations were as follow;

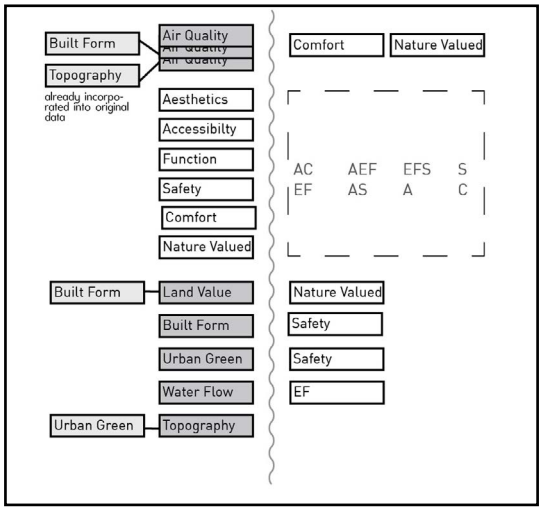
| | |
|---|---|
| High-low clusters | Points of survey markers surrounded by a low value of a chosen parameter |
| Low-High Clusters | Points not widely marked in the survey surrounded by high values of chosen parameter. |
| Moran's I | Evaluate autocorrelation.<br>1-0.5 for clustering<br><-0.5 for dispersion |

(table-16): Chosen indicators. H-L and L-H clustering will not always mean the same thing. Since the high and low values in each parameter imply different things.

The table describing the summary of the data research is shown on the next page;

The Spatial Analysis Toolbox 0.3 for QGIS was used to run Moran's I analysis.

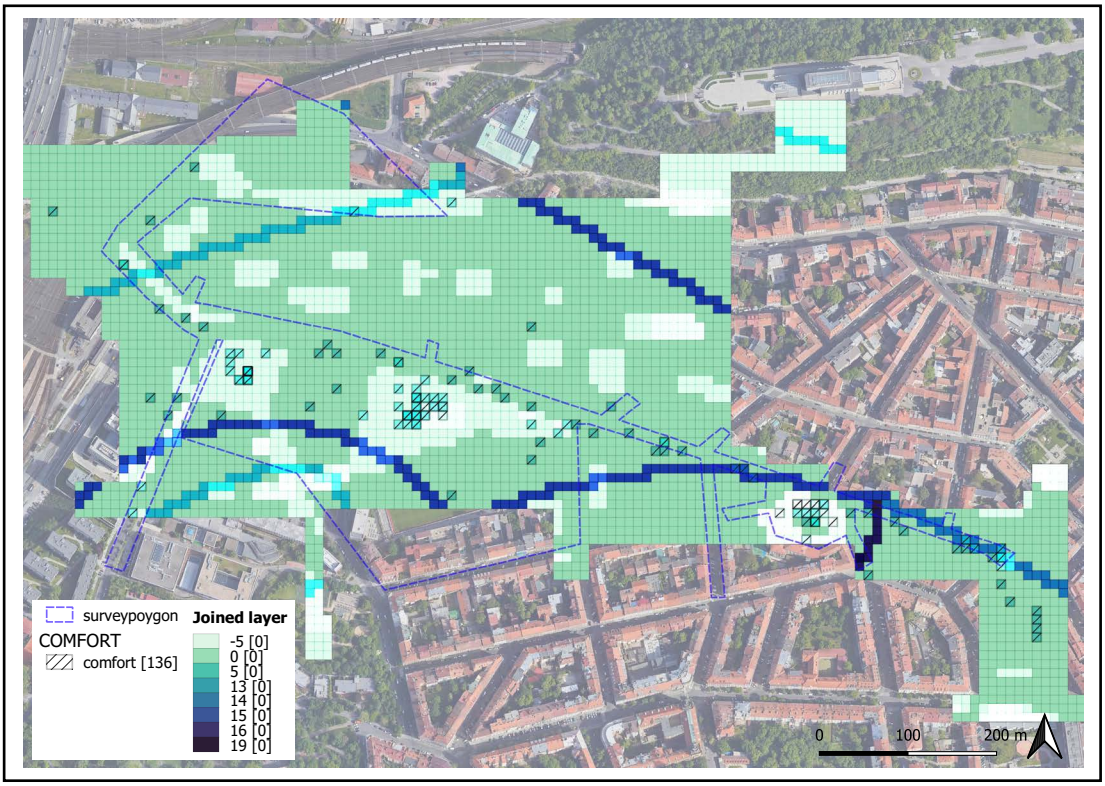
The selection was also informed by the '*benefits of green infrastructure (Hall, Vonderscher & Adkins 2010)*' (Table-6) described earlier in Chapter 1.




(fig-26): Study Selection Criteria, the correlations in between the shared values is already evident in the data.

| Chosen comparisons | 'Layers' Used © IPR Praha, © ČÚZK 2023 |
|---|---|
| 1. NATURE VALUES[d] (A Positive association with the presence or need of natural elements) and existing LAND VALUE[d] (monetary metric). | (Positive) nature relational values. Merged from the three groups (problems, values and potential). The recognition of lack of nature in 'problems' was considered as a positive value and thus could be aggregated into the combined data. |
| | Property values in CZK/m2, obtained as a discrete dataset, multiple factors have most likely come to establish these figures (such as historic significance, connectivity to services, overall aesthetic, up-keep). |
| 2. Existing URBAN GREEN INFRASTRUCTURE[d] and AREA TOPOGRAPHY[c] | Urban green land parcels and Tree point data, merged into one dataset. |
| | Land Topography, re-sampled to the study scale (10x10 m) |
| 3. SAFETY VALUES[d] and URBAN GREEN[d] / SAFETY VALUES[d] and BUILT URBAN FORM[d] | (Negative) safety values, The data was filtered by key words using Google sheet tools to distinguish between 'functional'/ accessibility' safety issues and so-called 'dubious characters in public spaces' safety issues, the later was used for this case. |
| | Urban green land parcels and Tree point data, merged into one dataset. |
| | Urban built form-void and "eyes on the street" (Jacobs, 1993); layer of building entry points that blur private and public, approximated for each building block. |
| 4. MICROCLIMATE[d] Creditworthiness and COMFORT VALUES[d] | Climate creditworthiness (1-good to 5-bad), pre-calculated 25 x 25 m scale data in three set ; air ventilation, velocity and urbanized zone micro-climate. |
| | (Negative) comfort values, The data was filtered by shared value code (F, E) to distinguish between 'functional'/'accessibility' comfort issues and actual human comfort issues. |

(table-17): Selected parameters and their proposed descriptions.




(table-17): Example of study input data, Grades (N) (good(1) to bad(5)) were already assigned to the climate "creditworthiness", the data to be compared (urban green) which would be assumed to be of low grade due to positive contribution to microclimate (N= -5) surveyed comfort values were assigned the highest grade 5 as they were strong feelings about the discomfort of the microclimate. altogether the grids were summed to create a mapping of 'climate values'.

*2.3.7 Calculations : Exploration and rules*

In order to reflect the nature of the selected parameters, a careful adjustment to the representative values were made, and data was combined based on realistic relations. (For example, the data for the air quality comfort and the physical safety aspect of certain spaces cannot be logically compared). This also reduces the number of tests that need to be processed in order to find potential relations and thus the search process was repeated with the suggested relations. The summary of adjustments that were learned from the process are as follows:

*1. The Moran's I value (that suggests the degree of pattern or dispersion and not pure chance) can return values that show high probabilities, however there were parameters that were discrete values yet were clustered and form patterns (such as air quality grades). These could be excluded from resulting graphics as they appeared as high-high clusters (see fig-27). In these situations, the overlay of the original survey markers, and interpretations of low-high or high-low clusters helped make a decision.*

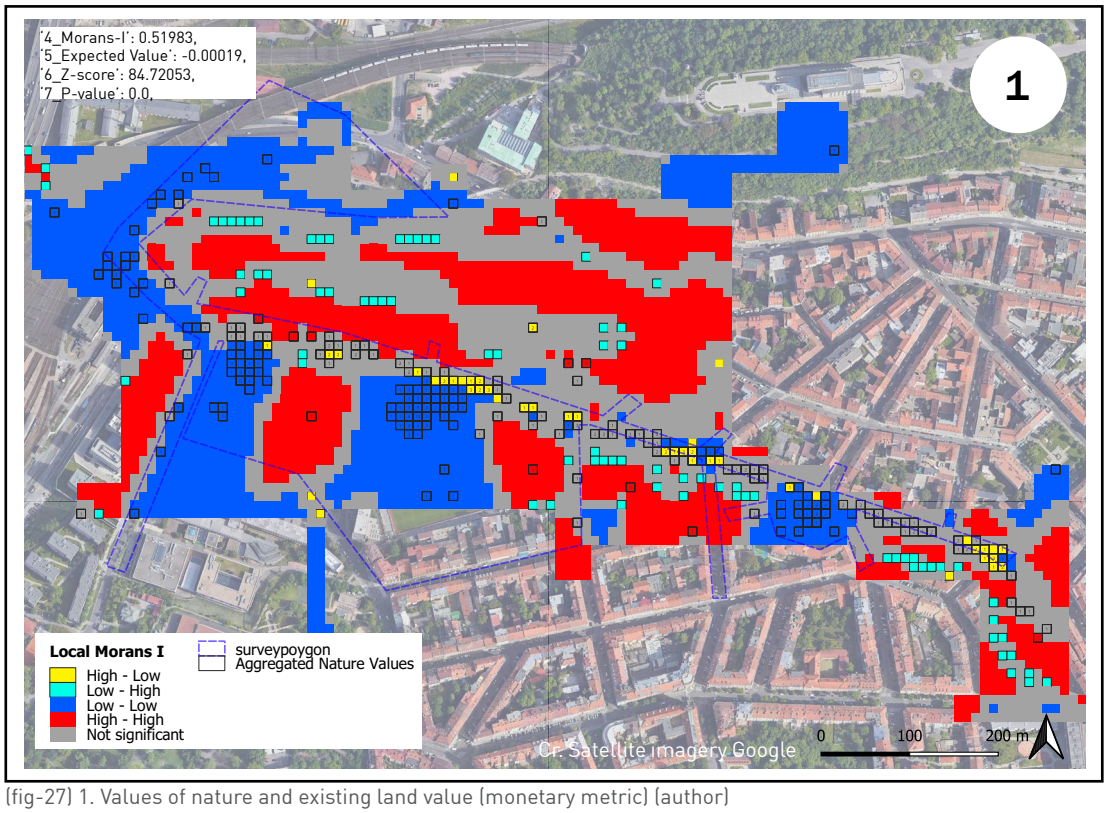
*2. Assigning numerical values to abstract indicators such as the shared values can be decided on a trial and error basis. The 'weight' of the grade can sometimes be a simple 1 to 1 comparison with the chosen parameter however in some cases, assigning higher or negative values helped (see fig 2a -2 e).*

*3. In some situations, the scale of the marker and the parameter were not comparable (such as water infiltration issue points and urban green/void layers). This would return skewed results and can be detected by clusters that are more-or-less equal to the original data input.*

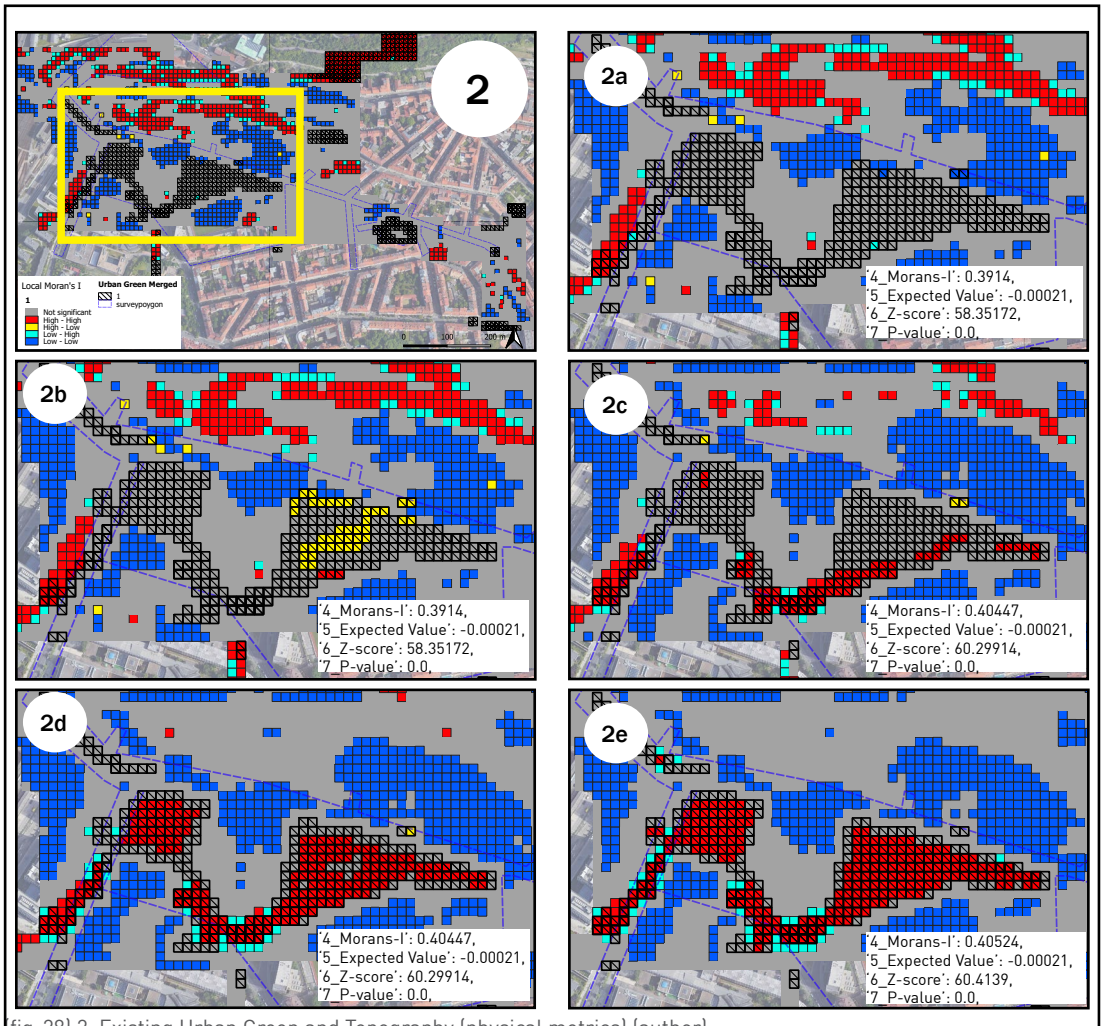
The five chosen studies summarise the common observations.

| **Chosen comparisons** | **Tested Values** |
|---|---|
| 1. NATURE VALUES[d]<br>LAND VALUE[d] (monetary metric). | N=1 |
| | N=(0 to 8) (0-35000 CZK/$m^2$ to 8 classes) |
| 2. Existing URBAN GREEN INFRASTRUCTURE[d]<br>AREA TOPOGRAPHY[c] | N=1 or N=10 or N=50 or N=90 |
| | N= (elevation in m re-sampled by 0.02) |
| 3. SAFETY VALUES[d]<br>URBAN GREEN[d]<br>SAFETY VALUES[d]<br>BUILT URBAN FORM and Void[s] | N=1 for negative-safety-marker |
| | N=1 |
| | Urban 'voids' N=2 (due to no negative-safety-value markers)<br>N=0 for negative-safety-marker |
| | N=0 for built form, N=5 for building entrances |
| 4. AIR/CLIMATE CREDITWORTHINESS[d] and COMFORT VALUES[d and] Existing URBAN GREEN INFRASTRUCTURE[d] | 3 datasets of N= (1-5) predefined in data |
| | N=5 as these were negative associates with climate comfort |
| | N=-5, assumed due to positive microclimate contributions |

(table-18): Selected parameters and their proposed valuations.

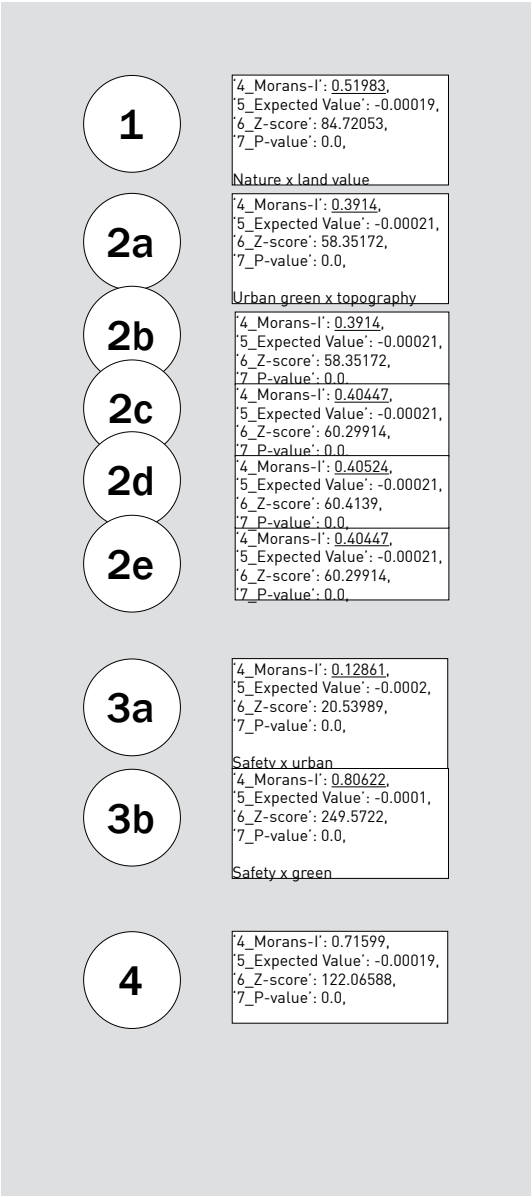



(fig-27) 1. Values of nature and existing land value (monetary metric) (author)




(fig-28) 2. Existing Urban Green and Topography (physical metrics) (author).

## 3. Results




(fig-29) The Moran's I values of the five studies, study-2 were multiple tests that returned a nearly null relation in each iteration.

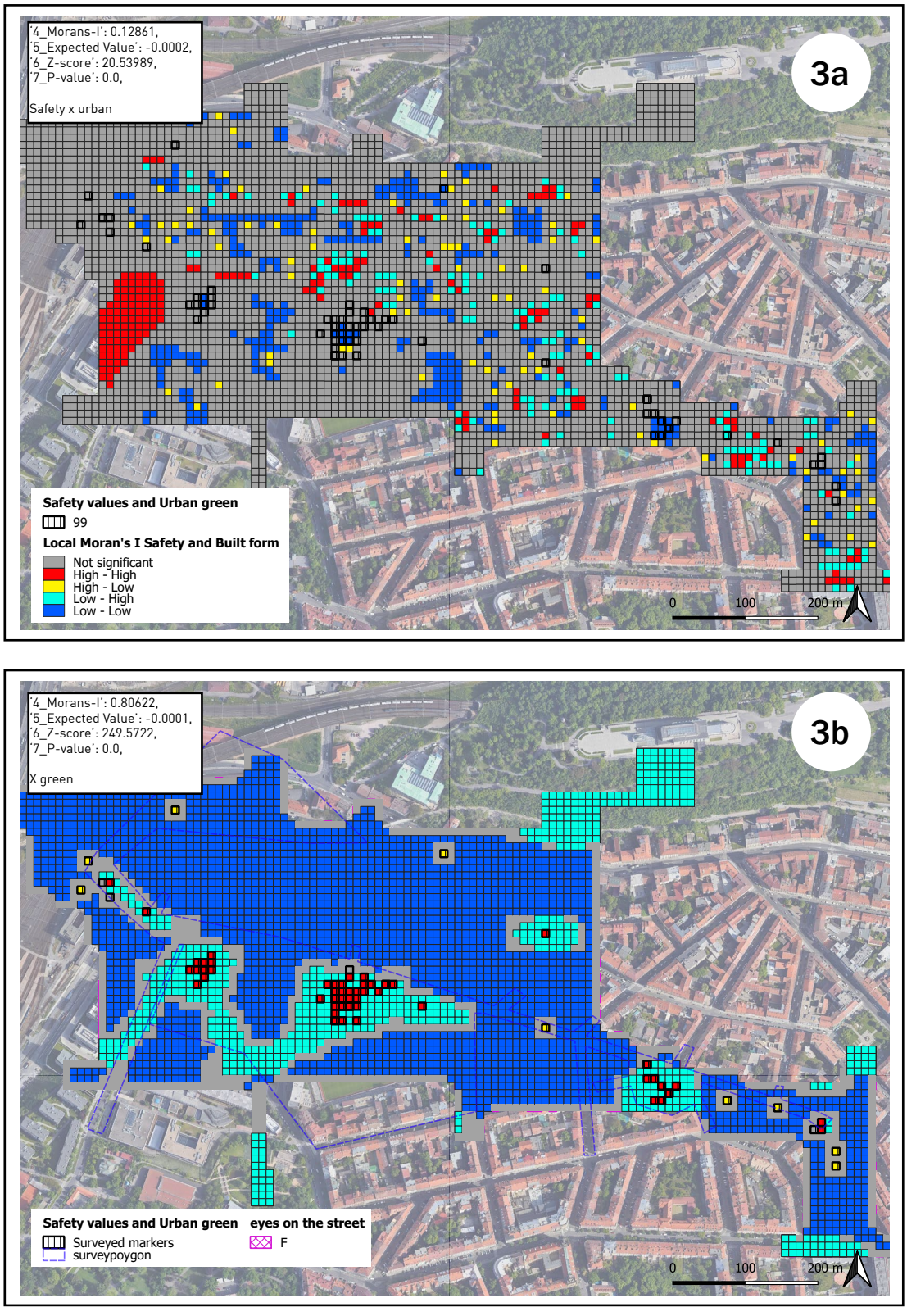
Each of the valuation and correlation studies provided different insights and challenges regarding the objectives of exploring rules that (as described) can "make visible, the values people/nature hold" and "contribute to decision-making".

Some relations were already apparent in the initial survey, while even some logical relations needed to be tested. As they are based on "agent-based-modeling", the relations or the lack of them can be described as 'behaviors".

*3.1 Results for apparent behaviors:*

The mapping of safety concerns and large units of urban green(fig-3b), which was made apparent in the survey as a very obvious correlation, was shown clearly in the simulation, inversely, the presence of public service buildings, did not find much relevance to the probability of a 'safety' concern occurring, other than the map visuals, even the Moran's I value showed great contrast ( 0.12 vs 0.8). (Value close to 0 indicates lack of correlation whereas values >0.5 indicate a strong relation) The same dataset also pointed out 'hot-spots' in non-green areas that in practice could probably be surveyed to find root-cause of 'safety concerns' (see fig-30).


(fig-30) safety concern hot-spot near the Lipanska street intersection, as indicated in the model. (Google street view 2023)




(fig-31) 3. Existing Urban Green and Safety concerns (physical metrics) (author).

In theory, the positive relation with the size of the urban green and the probability of safety concerns occurring, can be 'reverse-engineered' in studies where the 'safety' aspect of areas have not been surveyed, or need to be predicted.

*3.2.1 Results for plausible behaviors :*

The resulting mapping of urban green locations and the topography, which was assumed to be a likely relation, was not generated in the dataset as expected, the less-than-optimum but very close Moran's I value (~0.4) which stayed nearly constant through all iterations and the clustering visuals show that there the model is unable to establish this relation either a) it truly is not a huge factor 2) a lot other parameters need to be considered in the same model for it to show any pattern behaviors.

*3.2 Limitations*

The scale of the grid was moderately successful in facilitating reliable comparisons. The varying scales and sources of data posed a challenge as certain layers (such as rainwater infiltration issues) were highly specific and comparable data was not at the same granularity (urban green for example). In a urban transect study, smaller scales would be a priority as (surveyed) value indicators are more or less highly specific, discrete data points. The more city-scale dataset that are not continuous but simple clusters of similar discrete values have skewed correlation values and created issue for reliability on figures alone, and requires visual data to be interpreted in parallel. This occurred in micro-climate quality and comfort values model where the roughness of the climate data could not be compared to the highly discrete points of comfort values.

As an example, association of lower land values and occurrence of nature values (need for green elements) alternate from high-low clusters to no significant relation along the length of the street, this simulation most likely suffers from the scale of the data, as the nature values were collected at an individual level whereas the land price data is uniform over the comparison scale. For such particular situations, the surveyed points need to cover a more diverse (but contextually similar) site, in order to draw conclusions.

## 4. Discussion

The understanding of the physical world comes from observing it and connecting available information to form a world-view, but creation of something larger-than-life and change comes from collective actions, so it is understood in order to bring positive change in something that is the result of a collective, the initiative must also involve the same level of participation. Thus this act of identifying problems and proposing solutions need to be a rigorous process of sharing and refining the knowledge that is gathered.

Even problem identification itself is almost never a linear process and often times, a single perspective might never be able to capture the true cause and extent of a given issue. The inspiration for the study was a simple observation i.e., the urban interventions that are proposed as a solution for our wicked ecological problems tend not to match the scale of the problem itself or that the interventions tend not to be a part of a larger positive initiative, creating gaps where certain places are designed to over-perform while key locations might still suffer from ineffective practices, and stakeholders may not be invested in the ecological visions for their own cities and towns and this is maybe because urban environments are a complicated web of technologies and socio-economical factors.

So in order to design a system to reform the common practices, solutions should match the dynamic nature of the problem itself. So the starting point was, of course understanding how this dynamic nature is formed. The connection between the observation and the goal, which was to create transition paths to a sustainable future, was first bridged by an extensive literature review. The need to structure much more abstract and complex systems was a key point, as framing something that could be more qualitative in nature could reduce it to only its parts, erasing its essence in the process. So before the solutions that can become a decision-making tool, could be explored, the first section was dedicated to understanding and establishing the language that was needed to describe these much more intangible ideas. The IPBES 'Methodological Assessment Report On The Diverse Values And Valuation Of Nature' helped

| Objectives | Expected outcome |
|---|---|
| Reframing the issue of green infrastructure (GI) interventions in urban environments based on stakeholder perceptions and ecological goals. Exploring if synergy can be found between ecological and socio-economic values. | A valuation framework that is in-line with views of transition design, particularly concerning GI planning in an Historical Neighborhood infiill transect* |
| Explore rules that can govern optimum green infrastructure planning in Historical Neighborhood infiill transect* and represent them in dynamic models that react to evolving information. | Concentration of values and emergent behaviors made visible, to incorporate into decision-making processes. |

(Table-7). Overview of the two-part methodology (Author).

to avoid using language that could reduce human values of nature and their world to mere metrics and collections of numbers. The descriptors such as "shared values" and "broader values", invoke ideas which was a key aspect of the original goal, that the elements in a space are understood by their emergent properties rather than only their physical dimensions.

In an ideal world, systems could be explained in equal complexity with which they exist, but capacity for human knowledge build up and actions are limited by dimensions and reality of the world. While the issues could first be approached with more technical details such as physical constraints, the original idea was based rather on understanding attitudes and what change can be brought to rethink how we design our urban spaces.

In order to steer towards a desired vision, a problem statement and it's proposed solution might need to align itself with a larger movement that seeks to achieve similar goals. This resonance of ideas was an important lesson as we need to contribute in equal strength as the complexity of the issue itself, the recent developments in ideas of transition design, which seeks to understand and direct attitudes to a more just and ecological future was in line with the intention of the thesis. Once it was established that Rather than incremental changed to existing frameworks a more innovative, co created future is better suited to the current needs of our era (as we have learned that tried and tested practices have not amounted to the greater change we have expected). At this point the thesis had two parallel thoughts informing it. One, that we need to understand underlying values people hold for their physical world and how they envision it and what can be done to make it visible enough to elicit action and inform decisions.

In the era of big data, smart tools and accessible knowledge, the act of combining resources in a way that synergies can be discovered, can be a way to re-track common practices. In the case study selected for this thesis, it was found that the idea of revitalization of the historical neighborhoods in city of Prague, especially with an idea of becoming more ecological sustainable was already appearing in bits and pieces around the region like small blips on a radar map. With the framework built on understanding and making visible the values people may have, the growing practice of conceptual studies, that have been undertaken to implement visions for smaller localities, has the synergy potential that was previously mentioned. So this established practice and the valuation framework were "aggregated", in hopes of seeing the synergy.

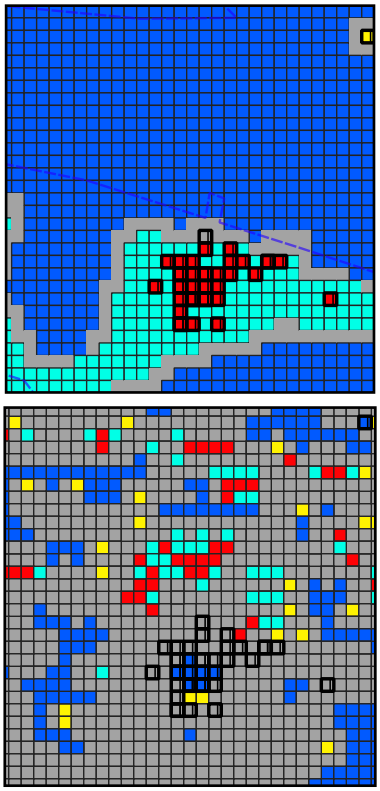
The selected simulations, informed by common shared values and related parameters showed great diversity in results which actually helped provide insights on the shortcomings and opportunities the vast amount of open data comes with. Certain models confirmed

common observations while other models exposed the limitation of data that simply lacked the complexity to be able to give a sure answer.

The original intention was, however to built redundancy and repetition in green infrastructure that performs well when it is found in abundance and is well-connected. The model which showed potential of concentration of need for nature could be become a tool for design and even reverse engineering, where these concentration are predicted or conditions are recreated to trigger the same concentration as an observed case.

Smart tools work on the rules that run behind the scenes. The simulations, could be presented in various mediums, but the underlying rules, as long as they are reliable can become a foundation for tools that can support the greater good.

The beauty of data visualization is in its ability to elicit a reaction from an audience. The resulting models in this study, beyond their numerical results, show patterns of interest, strong correlations that could inspire or complete randomness that could encourage new explorations.



(fig-32) same values, opposite parameters, resulting in complete pattern and complete randomness.

## 5. Conclusion

The vast amount of data available today has given planners and decision makers unprecedented tools to predict and shape the future of our Physical world. However, it is important to consider that the volume of data and the systematic approaches, are simply resources through which we can unravel the physical world and understand the more intangible aspects because these emergent behaviors and subjective values play a significant role in how spaces are occupied and used.

To create a more sustainable world that meets our goals and amplify positive outcomes, it is important to discover, make visible, and leverage these values as a means of driving change. This is an area of study that continues to be of great interest and importance to planners, designers, and community stakeholders alike, and one that will undoubtedly shape the future of our public spaces in meaningful ways, especially in the age of fast deteriorating environments.

There will always be trade-offs when these more abstract values are quantified or described in order to promote their contributions to the well-being of people and even more complexity comes into play when more eco-centric approaches are taken.

The results of the study shows the application of using data, that is collected through more systematic methods and from unlikely platforms. The lack of structure, does not need to be seen as a limitation, rather a way through which unexpected yet important relations can be understood. The discoveries can also help inform future approaches as data-collection can also be steered towards serving desired visions, which is a key point in the transition design pathways. The path should not have to be linear, in order for us to make change that sustains and creates ripples in systems.

It can be concluded based on the experimental models that academia can help planners and stakeholders create user-friendly tools that can help them visualize such emergent behaviors. So further simulations can be created in controlled environments and tried-and-tested tools may be made available, for people to freely access and gain insights and help them make informed decisions about their cities and for the nature.

## Data Sources

**Koncepční studie Seifertova Výsledky anketního průzkumu – sběr podnětů od veřejnosti červen** 2021

https://iprpraha.cz/uploads/assets/Seifertova/Seifertova_ZZ_2021_final.pdf

**Summary for policymakers of the methodological assessment of the diverse values and valuation of nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)**

https://explore.openaire.eu/search/publication?pid=10.5281%2Fzenodo.7410287

**Geografická data Prahy na jednom místě**

https://www.geoportalpraha.cz/cs/data/otevrena-data/seznam

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